Alberta
INFRASTRUCTURE AND TRANSPORTATION

Bridge Inspection & Maintenance System

BIM
Bridge Inspection and Maintenance

BIM INSPECTION MANUAL

Version 3.1

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Preface to Version 3.1

Technical Standards Branch

BRIDGE INSPECTION AND MAINTENANCE SYSTEM
INSPECTION MANUAL

(Release 3.1)

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Printed: March 2008

Preface to Version 3.0

Technical Standards Branch

BRIDGE INSPECTION AND MAINTENANCE SYSTEM
INSPECTION MANUAL

(Release 3.0)

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The information contained in this manual was revised and updated by Reg Quinton Consulting and Belke Consulting Ltd. with assistance on technical issues and editing from the Department Technical Review Committee. The previous version (2.0) was updated to reflect the changes made to the BIM inspection forms when the BIM system was transferred to the Department's Transportation Infrastructure Management System (TIMS). Additional information was added to clarify issues and correct errors in the previous version. Pictures and sketches were added to help illustrate sections of the manual.

Preface to Version 2.0

Technical Standards Branch

BRIDGE INSPECTION AND MAINTENANCE SYSTEM
INSPECTION MANUAL

(Release 2.0)

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The information contained in this manual was revised and updated by Assenheimer Consulting Ltd. with assistance on technical issues and editing from the Technical Standards Branch Review Committee. The previous version (1.4) of the manual was updated to reflect all the changes from the 1995 and 1997 seminars, clarify items that were sources of concern or problems and correct errors in the previous version of the manual. Additional information was added as required and additional guidelines for rating elements are provided. The Appendices of the previous manual (Version 1.4) have been removed and are bound in a separate BIM Reference Manual.

Preface to Version 1.4

Bridge Engineering Branch

BRIDGE INSPECTION AND MAINTENANCE SYSTEM
INSPECTION MANUAL

(Release1.4)

ACKNOWLEDGEMENTS

The information contained in this Manual was written by the BIM Committee which commenced work in June 1986 to develop a comprehensive computerized bridge and culvert inspection and maintenance system. This Manual complements the BIM system which was developed specifically for use by the Province of Alberta, Canada.

The BIM Committee consists of:

Ernie Waschuk	Bridge Inspection Manager (Chairman)
Jay G. Ramotar	Manager, Bridge Planning (Past-Chairman)
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The BIM committee would like to acknowledge the efforts of Bob Foster, Executive Director of Bridge Engineering Branch (retired Jan. 1987) for initiating this program; and Paul Carter for getting this project underway.

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1. CHAPTER 1 - BRIDGE INSPECTION AND MAINTENANCE SYSTEM

1.1. INTRODUCTION

The bridge inspection program is part of a comprehensive inventory and management data system. The three basic elements of the system are inventory, inspection and maintenance. The total system has developed in stages over a period of time. The Bridge Information System (BIS) was developed in the late 1960's and early 1970's and the Culvert Inventory System (CIS) was added later. In the mid 1980's development was started on the Bridge Inspection and Maintenance System (BIM) and in 1987 the inspection component of BIM was introduced. Further development on the system has taken place over the years. In the late 1990's, a corporate decision was made to combine all the Department information systems into a corporate database within the Transportation Infrastructure Management System (TIMS). The bridge inventory system (BIS and CIS) and the inspection system component (BIM) were moved into TIMS in 2005. This manual was developed to detail the operation of the BIM inspection component and this version of the manual (Version 3.0) incorporates changes that were made during the transfer to TIMS.

1.2. SYSTEM DEFINITION

The Bridge Inspection and Maintenance System (BIM) is a comprehensive inventory management system with the ability to process bridge inspection and component information for use in inspection management, maintenance programming, budget development, strategic planning, and life cycle planning so that the safety of the traveling public and the investment in bridge structures is optimized.

1.3. SYSTEM OBJECTIVES

The following briefly describes the primary objectives of the system:

- Provides a coordinated and systematic management facility to ensure an appropriate level of safety and convenience to the traveling public.
- Develops bridge management reports based on actual statistical information for budgeting and programming.
- Maximizes the life and serviceability of bridge structures by identifying potential problems at an early stage and initiates effective maintenance, rehabilitation, or monitoring schemes.
- Assists in predicting premature failures of bridge elements or life-span of different structure types using statistical analysis of inspection data, and identifies features unique to certain bridges for continued monitoring.
- Provides a computerized system for collecting, storing, processing, retrieving, and analyzing bridge inspection information. Also provides a reliable procedure for collecting, verifying, and updating inventory information for the Bridge Information System and/or auxiliary Data Files.

- Assists in providing data for prioritizing research, inspection, maintenance, rehabilitation, and reconstruction of bridges.
- Provides data for evaluating the effectiveness of design, construction, and maintenance policies and identifies areas that require development, revision, and/or research.
- Enhances the short and long term planning of manpower requirements, and the use of specialized equipment, specialized personnel, inspection methods, etc.
- Tracks pertinent maintenance items that will be used to estimate manpower requirements, quantities, costs, etc., for similar work.
- Provides for orderly review and follow-up on recommendations for maintenance and/or rehabilitation.
- Provides a framework for training bridge inspectors to ensure uniform evaluation of bridge conditions and sufficiency ratings.
- Generates tailored bridge inspection forms with BIS information on pre-determined time cycles or as required for all bridges.

1.4. SYSTEM FEATURES

The system was designed to include the following features:

- Constructed using the evolutionary (modular) approach in order to facilitate future changes. It is designed so that the use of certain functions or modules can be expanded or revised in the future without adversely affecting the overall performance of the system.
- Is menu driven, and all dialogues are as friendly as possible. The complexities of the system are not visible to the users. It has on-line HELP functions that are available to all users.
- Allows for the inter-connection with various communication facilities such as micro-computers, etc. and interacts with other data modules such as BIS, and those selected from outside the Department. Also, provides hardcopy outputs to the Regions through their remote and local printing facilities.
- Requires all users to be positively identified by password, identification number, and/or other means to protect the integrity of the system. It protects the integrity of all data files and the database; provisions for reconstructing data files are available if the files are accidentally destroyed.
- Contains a computer program that uses past inspection information for various types of statistical analysis.
- Provides versatile sort capabilities for generating reports. For example, identifying critical bridges or bridge elements that require monitoring.
- Provides direct access to individual data files through a menu format.
- Automatically updates the inventory information shown on the inspection forms when the individual data files are updated.
- Generates tailored bridge inspection forms at pre-determined cycles or as required.

- Automatically generates exception reports at pre-determined cycles to monitor follow-up recommendations for maintenance or rehabilitation.
- Automatically calculates the Sufficiency Rating and the Structural Condition Rating based on selected inventory and inspection items as well as a set of fixed formulas.
- Provides built-in on-line edit checks to detect certain types of errors, and automatically produces an edit report with error messages after input of inspection information.
- Has on-line capabilities for inquiry, data entry, and summary reports.
- Stores unlimited inspections on a single bridge for direct access or data manipulation.
- Can be accessed by more than one user simultaneously when requesting the same information or data file.

1.5. SYSTEM LAYOUT

The BIM system consists of a central database repository containing information for all bridges in the province. Access to the BIM system is web based and provides the ability to view and modify data by the users, depending on the security level assigned. The regional staff have access to enter, update, modify and/or delete data for bridge structures in their region. For bridge structures outside their region the regional staff have access to only view the data or generate statistical reports for all bridges in the Province. Whereas some Technical Standards Branch staff, who have responsibility for development and operation of the BIM system, have full access to all the system functions for all structures in the Province.

The three main elements in the system are inventory, inspection, and maintenance. They are a series of data files/modules in TIMS. These files can be accessed directly for obtaining summary reports or other forms of bridge data retrieval. Some of these files also provide the inspection forms which are used for in-depth investigation during a Level 2 inspection. These files can also be interfaced to provide Level 1-Level 2 combination reports. The system allows for the addition of new data files or modification of existing data files without affecting its operation.

1.6. SYSTEM OPERATION

Refer to the “BIS Inspections User Guide” for details on the following operational features:

- Authority to Use the System
- Sign-on Procedures
- System Menu
- Entering Inspection Information
- Update / Modification of Inspection Information
- Access to Auxiliary System Modules
- Generation of Blank BIM Reports

- Generation of BIM Reports with BIS & Last Inspection Information
- Generation of Standard Statistical Summary Reports
- Generation of Specialty Sorted Listings
- Generation of Specialized Reports
- Generation of Exception Reports

The system generates 13 types of single inspection forms and 12 common types of combination inspection forms as shown in Table 1.1. The type of report generated depends on the bridge file number which defines the principal and secondary span types from BIS. The single reports (TH to SIGN) are generated by using the principal span type only, e.g. the SG report is generated if the principal span type is RB, RC, RG, WG, or FR. The combination reports (THTT to DTSG) use the single report for the principal span type and the superstructure section of the single report for the secondary span type, e.g. the report for THTT consists of the single report for TH (through truss), and the superstructure section of the single report for TT (treated timber). The system will generate unique inspection form types if the combination of span types does not match the common combinations shown.

Before the inspection report is printed for a specific bridge site, the BIM system module:

a) extracts selected bridge inventory data from BIS, and the most recent AADT data from the Traffic Information System (Provincial Highways),

b) retrieves the last inspection information, including all condition ratings, explanation of condition, maintenance recommendations, and special comments for next inspection,

c) calculates the Structural Condition Rating and Sufficiency Rating based on the last inspection.

All this information is then printed on the report.

FORM TYPE	DESCRIPTION	SPAN TYPE
TH	Through Trusses	TH
PT	Pony Truss	PT
SG	Rolled Beams Riveted Plate Girders Welded Girders Steel Rigid Frames	RB RC RG WG FR
SS	Other Trusses & Arches	SS SSB SSA SSS SSF SSC
DT	Deck Trusses	DT
TT	All Timber Bridges	TT UT XT TP
PCS	Standard Precast Bridges	HH HC VH PG GR PE PA PS MM HCO PGO HHO PX PES PEF VS SM SMC SC SCC SMO VSO SCM SL SLC
PSR	Regular Prestress Bridge	RD FC VF PM VM PB DBT PQ PO PMO OM LF FM RM PJ NU CBT DBC CBC FCO PJO
CON	All Cast in Place Concrete Bridge Concrete Tee Girder Bridges Concrete Flat Slab Bridges	CA CB CF CV CX CC CXP CT CS
CUL1 CULM CULE	Single Culverts Multiple Culverts Culverts extended with different material and/or size	RP SP FP MP WP CP BP AP BPR RPB CPA CPE SPE PCB RPA RPE RPP MPB SCA SCR SSP CPP SPP SRA MPE
SIGN	Sign Structures	Z
THTT THPCS THPSR THSG THPT PTTT PTPCS SGTT SGPCS PSRPCS SSSG DTSG	Through Trusses with Timber Approaches Through Trusses with Standard Precast Approaches Through Trusses with Regular Prestress Approaches Through Trusses with Steel Girder Approaches Through Trusses with Pony Truss Approaches Pony Trusses with Timber Approaches Pony Trusses with Standard Precast Approaches Steel Beams with Timber Approaches Steel Beams with Standard Precast Approaches Regular Prestress with Standard Precast Approaches Special Steel with Steel Girder Approaches Deck Truss with Steel Girder Approaches	

Table 1.1 - BIM Report Index

1.7. FEATURES OF THE BIM REPORTS

The BIM reports are designed to:

a) meet the objectives and goals of the system
b) provide pertinent bridge data to the inspector
c) be as simple as possible for use in the field

Some of the features of the reports are:

1. Tailored single reports for various primary span types.
2. Tailored combination reports for various primary and secondary span types.
3. Provides inventory data that is important for proper inspection from BIS.
4. From the Bridge Rating Information System (BRIS), provides rated loading (when available), of the governing span for three types of rating truck configurations as well as the governing critical member for each truck type. Whenever the rated loading is not available, the design loading is provided.
5. Provides a condition rating of each bridge element, as well as space for ‘Explanation of Condition’.
6. Provides a general condition rating for each major category after detailed inspection and rating of each element by the inspector.
7. Provides a tailored list of recommended maintenance items for various principal span types.
8. Provides a space to note special comments or instructions for the next inspection.
9. Provides scheduling, and cost estimates of important maintenance recommendations.
10. Prints all inventory data, condition rating, explanation of conditions, etc., to be used for the next inspection.
11. Provides for two levels of inspection.
12. Provides the Structural Condition Rating and the Sufficiency Rating based on data from the last inspection.
13. Provides a clear indication when a bridge element is either not accessible or not applicable.

1.8. FORMAT OF THE BIM REPORTS

Each BIM report is tailored for the specific bridge structure, and is designed to provide selected inventory information from BIS and all the ratings and comments from the last inspection.

There are two columns that are used for ratings: the 'Last' column contains the ratings that were assigned during the last inspection, and the 'Now' column is left blank for the upcoming inspection. The space within each column that is shaded does not require a rating.

The inspection items are grouped into categories which are placed in a sequence that duplicates the normal inspection sequence in the field. A general rating is required for each of these categories (see section 1.10).

The BIM report is structured as follows:

Bridge Inventory Information

Most of this information is printed on the top of the first page but some of this information is provided at appropriate locations within the report. The data fields on the form where inventory information has been provided or will appear are shaded. Whenever an inventory item is not available in BIS the field is left blank but the area still appears shaded. If the missing inventory information can be determined by the inspector, it should be recorded in the blank shaded field. The inspector is also expected to review the existing inventory data for correctness and accuracy and provide corrections if required. See "Bridge Information System (BIS) for Inspection Consultants User Guide" for instructions on updating inventory information.

Posting Information

The vertical clearance section appears only on bridges that are used as grade separations or pedestrian overpasses, and those with one or more Through Truss span. The load posting section appears on all bridge forms but load posting is only required at bridges that have allowable loading less than the legal loading. The load posting section does not appear on culvert forms.

Utilities

This section is common to all BIM reports.

Approach Roads

For all BIM reports there is a common section for all culverts and a common section for all bridges.

Superstructure

This section is unique to the type of BIM report (Form ID).

Substructure

This section is also unique to the type of BIM report (Form ID).

Channel

This section is common to all reports except those for bridges or culverts that are used as grade separations or pedestrian overpasses. For these bridges the channel section is replaced with a grade separation section that allows inspection of the opening under the structure.

Maintenance Items

The last page provides for maintenance recommendations, special comments, follow-up, etc.

1.9. BIM CONDITION RATING SYSTEM

A brief description of the condition rating system is given in Table 1.2. It consists of a numerical rating range of 1 to 9. This rating applies to all inspection elements as well as the general rating for each category. The rating is representative of the condition of the element and the ability of the element to function as originally designed. It does not consider the standard of the element compared to current design standards, e.g. a substandard bridgerail can be rated 9 if it is in excellent condition.

The two important considerations when determining the proper ratings for bridge and culvert elements are condition and functionality.

- Is the element in an acceptable condition?
- Is the element functioning as designed?

Additionally, the rating of the element also reflects any safety concerns and maintenance priority.

The rating of an element is determined by the rating of the worst item within the group. It is not intended to be an overall representation of the condition and functionality of all the items. For instance, a bridge may have 15 bridgerail posts with only one that is broken and rated 3. Even though the other 14 posts are in good condition and rated 5 or more the rating for the 'Bridgerail Posts' element is 3. The inspector should describe, in the 'Explanation of Condition', why the post has a low rating and where it is located. However, for some of the failure critical elements such as timber stringers, caps and piles as well as precast concrete girders, the number of units that are rated N, 1, 2, and/or 3 are recorded in a 'Detail Rating' table and the lowest of these is recorded as the element rating.

Blank ratings are not allowed on the form. Each element is assigned a rating of 1 to 9, N or X. The rating of the element is based on what the inspector can see. The inspector should be able to see enough of the element to be comfortable assigning a rating. If the element is inaccessible or enough is not visible for the inspector to confidently assign a rating, the element is rated N. If a particular element does not apply to the structure being inspected, the element is rated X.

In situations where an element does not exist but is required in the judgment of the inspector, the element is rated X with a comment provided in the 'Explanation of Condition' along with a maintenance recommendation. For example, a bridge site may not have any guardrail, but it is required in the judgment of the inspector. The Guardrail is rated X and comments are provided in the 'Explanation of Condition' along with a maintenance recommendation for installation of guardrail.

Rating		Commentary	Maintenance Priority
9	Very Good	New condition.	No repairs in foreseeable future.
8		Almost new condition.	No repairs in foreseeable future.
7	Good	Could be upgraded to new condition with very little effort.	No repairs necessary at this time.
6		Generally good condition. Functioning as designed with no signs of distress or deterioration.	No repairs necessary at this time.
5	Adequate	Acceptable condition and functioning as intended.	No repairs necessary at this time.
4		Below minimum acceptable condition.	Low priority for repairs.
3	Poor	Presence of distress or deterioration. Not functioning as intended.	Medium priority for replacement, repair, and/or signing.
2		Hazardous condition or severe distress or deterioration.	High priority for replacement, repair, and/or signing.
1	Immediate Action	Danger of collapse and/or danger to users.	Bridge closure, replacement, repair, and/or signing required as soon as possible.
N	Not Accessible	Element cannot be visually inspected.	
X	Not Applicable	Element not applicable to this bridge.	

Table 1.2 - Condition Rating System

The rating also reflects the priority or urgency for maintenance. The urgency for maintenance also depends heavily on the importance of the element relative to the safe function of the structure. As a general guideline the ratings could be related to the following priorities:

4 - low priority
3 - medium priority
2 - high priority
1 - immediate action

See section 11.2.2 for more details on maintenance recommendations.

1.10. GENERAL RATING

The inspector is required to provide a general condition rating after rating all the individual elements for categories of approach road, superstructure, substructure, channel, grade separation, culvert ends and barrel. It should reflect the condition of each category in accordance with Table 1.2, and includes the impact of the condition of key elements within the category on the structural integrity and safety of the bridge. For example, a timber cap with a rating of 2 would indicate a substructure general rating of 2 as well. On the other hand, a poor rating for non-load carrying elements such as the wearing surface should not significantly affect the superstructure general rating.

The general rating for each category is governed by the ratings assigned to critical load carrying elements or members of the structure. The general rating must also reflect any safety concerns related to the function of the structure. The general rating is not an average of the element ratings.

In most cases the general rating cannot be higher than the lowest critical element rating. For example, a girder rating of 3 would require the superstructure general rating be rated 3. The general rating could be lower than the critical element rating if another non-critical element presents a safety concern. For instance, if a section of bridgerail has been destroyed or if water ponding on the approach are safety concerns and rated 2, then these will govern and result in a general rating of 2.

There may be situations where critical elements are not accessible and are rated N. For culverts where the barrel section is inaccessible and the critical elements are rated N the general rating may be rated N or in some instances the previous general rating may be carried over. If a critical barrel element was previously rated 4 or less, resulting in a general rating of 4 or less, the previous general rating must be carried over. A comment must be provided in the 'Explanation of Condition' indicating this. On the other hand, if the previous critical element ratings resulted in a general rating of 5 or greater, the general rating should be N. This is done because if the culvert barrel general rating is N, the system defaults to a general rating of 5 for the calculation of the Structural Condition Rating. Additionally, if the general rating on the previous inspection was rated N and the general rating on the current inspection is rated N, the inspector must review the previous inspections for when the culvert barrel was last accessible for inspection and confirm that the N rating has been carried forward correctly.

For other category general ratings where the elements are inaccessible, carry over the previous inspector's general rating unless another critical element governs. For example, previous ratings show the girders rated 5, deck underside rated 6 and the superstructure general rating as 5. The current inspection does not allow an adequate view of the girders to comfortably assign a rating. However, cracks are noted on the deck underside near the abutment and the deck underside is rated 4. In this situation, the girders would be rated N but the superstructure general rating would be lowered to 4 to reflect the deck underside rating of 4.

There may be situations where an element is rated X since it does not exist (e.g. no approach railing, no bridgerail) but the non-existing element results in a hazardous condition. This would be noted as hazardous by the inspector in the 'Explanation of Condition'. In this situation the general rating would be governed by this non-existing element and rated 2 unless another element had a lower rating.

The following are some guidelines for establishing the general ratings for each category:

1.10.1. Approach Road

The approach road general rating is governed by:

- horizontal alignment rating
- vertical alignment rating
- safety concerns (e.g severe approach bump, improper installation of warning signs)
- potential hazards due to drainage problems such as ponding or icing
- a missing approach railing rated X may govern the general rating if it creates a hazardous situation (i.e. rate 2)

1.10.2. Superstructure

The superstructure general rating is governed by:

- ratings for structural load carrying elements
- subdeck or deck underside rating
- girder or stringer rating
- safety concerns (missing bridgerail section, severe span alignment problems, severe bump, etc.)
- potential hazards due to drainage problems such as ponding or icing
- a missing bridgerail that is rated X may govern the general rating if it creates a hazardous situation (i.e. rate 2)

1.10.3. Substructure

The substructure general rating is governed by:

- ratings for structural load carrying elements
- bearing seat or cap rating
- pile rating
- backwall rating of 2 or less
- stability rating

The element ratings for both the abutment and pier must be taken into account when assigning the overall substructure general rating.

1.10.4. Channel

The channel general rating is governed by:

- channel alignment rating
- bank stability rating of 4 or less
- slope protection rating
- adequacy of opening rating

1.10.5. Grade Separation

The grade separation general rating is governed by:

- road alignment rating
- traffic safety features rating
- bank stability rating
- drainage rating

1.10.6. Culvert Approach Road

The culvert approach general rating is governed by:

- horizontal alignment rating
- vertical alignment rating
- embankment rating of 3 or less

1.10.7. Upstream/Downstream Culvert Ends

The culvert end general ratings are governed by:

- headwall rating
- collar rating
- wingwall rating
- cutoff wall rating
- bevel end rating
- scour protection rating

1.10.8. Culvert Barrel

The culvert barrel general rating is governed by:

- ratings for structural load carrying elements
- roof rating
- sidewall rating
- circumferential seam rating of 2 or less
- longitudinal seam rating
- corrosion rating of 2 or less
- waterway adequacy rating of 2 or less
- floor rated 3 or less will influence general rating

1.10.9. Culvert Channel

The culvert channel general rating is governed by:

- channel alignment rating
- bank stability rating of 4 or less
- significant accumulation of drift

1.10.10. Culvert Grade Separation

The culvert grade separation general rating is governed by:

- road alignment rating
- roadway surface rating
- traffic safety features rating
- drainage rating

1.10.11. Sign Structure Approach Road/Safety Features

The sign structure approach road/safety features general rating is governed by:

- horizontal alignment rating
- vertical alignment rating
- safety concerns with traffic safety features or guardrail

1.10.12. Sign Structure Substructure

The sign structure substructure general rating is governed by:

- pedestal rating
- column rating
- connections rating

1.10.13. Sign Structure Superstructure

The sign structure superstructure general rating is governed by:

- load carrying elements in the superstructure
- any safety concerns related to any item on the superstructure

1.10.14. Sign Structure Sign

The sign structure sign general rating is governed by:

- sign board rating
- connections rating
- coating rating
- illumination rating

1.11. EFFECT OF REPAIRS ON ELEMENT RATINGS

1.11.1. Temporary Repairs

A temporary repair is intended to be in place for less than two years. These temporary repairs have no effect on the rating of the element. For example, a bridgerail section may have been severely damaged by a vehicle collision and was rated 2. As a temporary safety measure, flexbeam guardrail is strapped over the damaged bridgerail section. However, the damaged bridgerail will remain rated as 2 until permanent repairs are made.

It may not always be apparent whether a repair is intended to be temporary or permanent. The inspector is to apply judgment when making this determination. The temporary repair may also be a special feature and thus require a condition rating.

Some examples of temporary repairs are:

- flexbeam guardrail strapped over damaged bridgerail section
- pile bent on mudsills
- non-permanent culvert struts

1.11.2. Permanent Repairs

Permanent repairs are intended to be in place for more than two years. When assigning a rating, the inspector must consider the effect of the repair. An element might be completely replaced and the effect of the repair would be to increase the element rating to 9. Alternatively, a permanent repair might be made simply to restore the element to an acceptable level of condition and functionality and therefore have a rating of 5.

Some examples of permanent repairs are:

- steel cap replacing treated timber cap
- shotcrete repair over a cracked culvert seam
- equivalent timber stringer inserted beside a broken stringer
- steel banding of timber piles
- permanent struts (steel struts or timber struts in place for more than two years)

1.12. GENERAL FORM COMPLETION

1.12.1. Verifying and Updating Inventory Data

During the inspection, all inventory items that can be reasonably updated and verified in the field are to be obtained, verified or revised by the Inspector. Each verified inventory data item is to be checked off to indicate that the data item was verified. Attempts should be made to confirm and verify this information and provide corrections when errors are found.

The inventory data is stored in the various modules of TIMS. Information on updating inventory data can be found in the “Bridge Information System (BIS) for Inspection Consultants User Guide”.

The design culvert dimensions are stored in the Culvert Information System (CIS) module and are provided on page 1 of all culvert forms in the culvert information section under span and rise. The design dimensions are used to determine sagging and deflecting measurements in the barrel section. Large differences between the design and measured dimensions of a culvert without deformations could indicate that incorrect design dimensions are recorded on the form.

For inventory data, changes are made by crossing out the recorded value on the form and writing in the new information. Inventory data is to be updated on the form. However, minor changes to data items like roadway width are not required.

1.12.2. Supporting Information

All ratings of 4 or less must have an ‘Explanation of Condition’ provided by the inspector.

Ratings of 3 or less must have an ‘Explanation of Condition’ and a recommendation for action in the maintenance recommendations on the last page of the form. The action may be in the form of recommending repairs and maintenance, monitoring the element on a shortened inspection cycle, posting the structure for a lower allowable load or other appropriate action. Appropriate photographs, measurements and/or sketches are also to be provided for ratings of 3 or less. All maintenance recommendations regardless of rating must be accompanied by a photograph.

1.12.3. BIM Y/N Inventory Questions

Throughout the inspection form, Y/N (YES/NO) inventory questions are asked. When answering Y (YES) to these questions, an ‘Explanation of Condition’ is required.

Similarly, there are Y/N questions where answering N (No) requires an ‘Explanation of Condition’. These include:

Guardrail:	Current Standard	Y/N
Bearings:	Coating Adequate	Y/N
Functioning		Y/N
Longitudinal Seams:	Proper Lap	Y/N
Longitudinal Stagger		Y/N

1.12.4. Significant Changes From Previous Rating

Usually the condition of bridge elements decrease slowly over the life of the structure, but sometimes an element's condition or functionality may change significantly over a given inspection cycle but still be considered adequate and be rated 5 or more. If the change in condition or functionality is unexpected, describe why the rating has changed in the 'Explanation of Condition'. For instance, treated timber piles may have been rated 8 in the previous inspection. After 21 months, the piles are rated 5. In the 'Explanation of Condition', describe why the rating has changed so significantly.

Examples of some elements not expected to change significantly under normal conditions over a given inspection cycle are:

- prestressed girders
- truss members
- bearings
- deck joints
- timber piles

There are elements which are expected to deteriorate over a given inspection cycle. For example, it is not unreasonable to have the rating of a timber stripdeck wearing surface change from a rating of 8 to a rating of 5 or less over a 57 month inspection cycle.

1.12.5. Measurement Based Ratings

When ratings are based on measurements, such as the culvert roof and sidewall rating, the measurements must be taken and recorded along with the location of the measurement.

1.12.6. Previous Comments and Measurements

Comments from previous inspector that still apply must be checked off by the inspector. Comments from the previous inspection which no longer apply must be crossed out by the inspector. In situations where the element cannot be seen or is not accessible, the comments are to be retained and the date the comment originated added to the comments. Initials of the previous inspector are not required.

Additionally, in situations where the inspector cannot confirm or deny the information shown, the comments are to be retained with the date the comment originated. This valuable information might be measurements that cannot be verified, high water marks, information recorded during a certain season or information recorded during a particular weather condition (rain, snow, etc.).

1.12.7. Photographs and Sketches

Photographs and sketches are an excellent means of providing supporting information. The inspector must submit two copies of all photographs with the inspection form. A third set could be made if the Municipality intends to retain a copy of the inspection in their own files. Photographs should be mounted on separate sheets and supplemented with a written description next to the photograph.

The photographs are intended to be additional supporting information. All ratings of 4 or less must still have an 'Explanation of Condition' on the inspection form. The

‘Explanation of Condition’ may refer to a photograph but it is unacceptable to only write "SEE PHOTO" in the ‘Explanation of Condition’ area on the inspection form.

All maintenance recommendations regardless of the rating must be accompanied by a photograph.

A sample format for mounting photographs is shown in Figure 1.1. The sample is intended to show the format for the placement of the photographs and the associated comments. The sample is not intended to show the type of pictures to provide with the inspection.

Photographs should meet the following requirements:

- Photos must be mounted 2 per page (8 ½ X 11).
- Photos must be clear and show the defect.
- Digital cameras may be used (Minimum 3 megapixels).

Place Road Authority Name and/or Consultant's Name here.		File No.:	**Bridge File Number**
		Date:	**Date**
Stream:	**Stream Name**	By:	**Inspector's Name**
Highway / Location:	**Highway / Closest Town**	Page:	**# of #**

	Looking west at the alignment. Notice no vertical clearance sign on the bridge and ponding along the north gutter.
	The turndown end was left too high at both east ends.

Figure 1.1 - Sample Photo Mounting

2. CHAPTER 2 - BIM USER GUIDELINES AND RESPONSIBILITIES

2.1. BRIDGE INSPECTOR'S QUALIFICATION & CERTIFICATION

A bridge inspector is a specialist who has a unique combination of technical knowledge in bridge engineering, bridge inspection experience, and familiarity with condition rating procedures and the BIM inspection reports. The integrity and effectiveness of the BIM system depend on the quality of inspection and inventory data provided by the inspector.

BIM bridge inspectors are classified as either Class A or Class B inspectors.

2.1.1. Class A Inspectors

A Class A inspector is certified to inspect major bridges, standard bridges and culverts. The minimum qualifications are:

1. A Civil Engineering Degree from an accredited university plus two years related bridge experience, or
2. A Technical Diploma in Civil Engineering Technology plus three years of related bridge experience, or
3. Equivalent combination of education and experience consistent with items 1 or 2 above.

In addition the following requirements must be met:

- Successful completion of the prescribed Class A and Class B Bridge Inspection Training Courses.
- Structured bridge inspection training directly supervised and instructed by a Certified Class A Inspector/Trainer.
- Additional self-directed bridge inspection work experience that is monitored/ reviewed by a Certified Class A Bridge Inspector/Trainer. The amount of field inspection training and work experience required will depend on the ability and knowledge demonstrated by the trainee.
- Successful completion of Class A Inspection Examination and Test Inspections.

2.1.2. Class B Inspectors

A Class B Inspector is certified to inspect standard bridges and culverts only. The minimum qualifications are a High School Diploma or equivalent combination of education and experience in addition to the following:

- Successful completion of the prescribed Class B Bridge Inspection Training Course.
- Structured bridge inspection training directly supervised and instructed by a Certified Class A Inspector/Trainer.
- Additional self-directed bridge inspection work experience that is monitored/ reviewed by a Certified Class A Bridge Inspector/Trainer. The amount of field

inspection training and work experience required will depend on the ability and knowledge demonstrated by the trainee.

- Successful completion of Class B Inspection Examination and Test Inspections.

2.1.3. Certification

Class A and Class B inspectors will be certified by a three-member committee who will review the candidate's training record to determine if requirements have been met.

Class A and Class B inspectors' certificates are valid for a maximum of three years. Renewal is granted if there has been significant involvement with bridge inspection during the previous certification period so that bridge inspection ability and knowledge can be maintained and quality of inspection work has been at an acceptable level.

In addition, any upgrading and refresher courses or seminars that are offered or prescribed by the Department during that period must have been successfully completed.

2.2. Responsibilities For Bridge Inspection Within The Department

The following guidelines define the responsibility of various bridge groups in the Department with regard to scheduled bridge inspections for which the Department is responsible.

The **Bridge Manager** is responsible for:

- Arranging for inspections and entry of data at the prescribed intervals or at shorter intervals as deemed necessary by condition to identify maintenance needs and rate the condition of pertinent elements and components.
- Arranging for inspection by other forces with specialized equipment or expertise where the usual means of inspection is not adequate for a proper assessment.
- Initiating appropriate action and/or notifying the responsible road authority where deficiencies are identified.
- Control and management of bridge structures for which the Department is the responsible road authority.

Technical Standards Branch - Bridge Engineering is responsible for:

- Development, implementation and overall management of the BIM system which includes establishment of inspection and maintenance standards, policies and procedures, training for inspection, and monitoring of inspections to ensure standards, policies and procedures are maintained.
- Providing technical support and specialized services for the inspection programs.
- Management of the BIM system module data.

2.3. MUNICIPALITY RESPONSIBILITIES

Municipality inspectors are reminded that under current legislation, control and management of the structures on local roads remain with the road authority at all times. Under established guidelines, the Municipalities are responsible for:

- Inspection of culverts and standard bridges
- Monitoring condition and serviceability of major bridges
- Signing at bridge structures
- Certain types of routine maintenance

2.4. MUNICIPALITY INSPECTION PROCESS

The Bridge Managers send out inspection forms for culverts and standard bridges where the responsible road authority is not the Department. Inspections are scheduled so that a certain number of structures are due every year. This is done to even out the work load and maintain the inspector's skills and expertise. It should also be noted that certified Class B inspectors are required to remain active in bridge inspection to maintain their certification.

The Department engages the services of an engineering consultant for each Region to review and input inspections completed by or for the Municipalities. Once the road authority has completed the inspections, they are to be forwarded, with all supporting documentation, to the consultant.

The consultant will review the completed forms to ensure:

- Ratings are assigned according to the Bridge Inspection and Maintenance System (BIM) rating system
- All element ratings and general ratings are entered on the form
- All inventory information has been verified or updated
- Explanations of condition are given for all ratings of 4 or less
- Ratings of 3 or less are supported by photographs and/or sketches and have an accompanying recommendation for maintenance/monitoring or other appropriate action
- Ratings and maintenance recommendations are consistent with the explanations of condition and supporting documentation

If the completed inspections are found to be unsatisfactory, they will be returned to the inspector. The inspector is required to revise the forms accordingly and resubmit them to the consultant. The consultant will then review the revisions and input the data into the system. If the information on the form is still found to be unsatisfactory after the revisions, it may again be returned to the inspector.

If the inspector has any concerns or questions regarding the review of the inspection, they may contact the Bridge Manager.

2.5. FREQUENCY OF BRIDGE INSPECTION

Presently, Provincial Highways consist of 2 digit and 3 digit highways (e.g. Hwy 16 and Hwy 611). The 2 digit highways were previously known as Primary Highways and 3 digit were known as Secondary Highways. All bridges are to be inspected in accordance with the following intervals to ensure an appropriate level of safety:

1. Major Bridges, Standard Bridges, and Culverts on Provincial Highways (including Approach roads) with numbers less than 500 or greater than or equal to 900 - 21 months.
2. Major Bridges, Standard Bridges, and Culverts on Provincial Highways with numbers equal to or greater than 500 but less than 900 - 39 months.
3. Major Bridges on Local Roads - 39 months.
4. Major Bridges in parks that carry pedestrian traffic only – 57 months.
5. Standard Bridges and Culverts on Local Roads – 57 months.
6. All new bridge structures are to be inspected immediately after construction is complete and within 24 months after completion as part of the warranty inspection, where applicable.
7. All bridge structures are to be inspected immediately after any significant maintenance or rehabilitation has been completed.

These intervals must be adhered to within reasonable limits. The inspector may specify shorter intervals depending on the age, traffic characteristics, known deficiencies, etc. of the bridge. It is intended that these cycles will provide the benefit of inspecting each bridge and culvert during different seasonal conditions.

2.6. LEVEL OF BRIDGE INSPECTION

Most major bridges, standard bridges, and culverts can be adequately inspected by a certified bridge inspector on a routine basis (Level 1). However, certain major bridges or components of standard bridges and culverts require inspection with specialized knowledge, tools and equipment. Almost all bridges will require at least two specialized inspections (Level 2) during their life-span. Specialized inspection includes ultrasonic tests on steel, CSE tests on deck concrete, coring of timber caps and/or corbels, etc. Level 2 inspections are essential for high load and overload damage, flood damage or where critical or significant deficiencies are known or suspected.

2.6.1. Level 1:

Level 1 is a general inspection which requires completion of the BIM report and use of basic tools and equipment. This level of inspection must be undertaken by certified bridge inspectors and must be performed at time intervals not exceeding those specified by policy.

2.6.2. Level 2:

This is an in-depth inspection which requires completion of the BIM report, the appropriate Level 2 reports, and use of specialized tools, techniques, and equipment. This inspection will normally be undertaken by certified bridge inspectors who have the required specialized knowledge or training.

More information on Level 2 inspection forms and processes can be found in the BIM Level 2 Inspection Manual.

2.7. ACCESS AND DATA ENTRY AUTHORITY FOR THE BIM SYSTEM

The following guidelines define the responsibility and procedures for accessing and entering data into the system:

1. The Bridge Manager is responsible for the entry of scheduled bridge inspection information for all bridges located in the region. Access for inputting or updating inspection information is provided only to the Bridge Manager or Technical Standards Branch – Bridge Engineering Section. This responsibility may be delegated to a Consultant under contract to the Department to complete this task.
2. Scheduled inspections done by the rural municipalities or consultants on behalf of the rural municipalities must be submitted for review and data entry to the Bridge Manager or the Consultant delegated by the Department.
3. The Technical Standards Branch - Bridge Engineering is responsible for the entry of data from specialized inspections into the auxiliary modules created for this purpose. Specialized inspection information by others must be submitted for review and data entry to the Technical Standards Branch - Bridge Engineering.
4. Urban municipalities are allowed limited access to the system, if requested. Access is limited to bridges located within the city. The urban municipalities will be responsible for data entry and update of all their bridges.
5. Special agreements can be made between the Department and smaller urban municipalities on the use of the system.

2.8. REPORTING PROCEDURES FOR SCHEDULED BRIDGE INSPECTION

Inspections are scheduled to ensure that:

1. The findings in the field are reported in a systematic and organized manner.
2. The proper expertise is applied for maintenance and rehabilitation, and follow-up on maintenance recommendations.

The following guidelines define the reporting procedures:

1. All scheduled bridge inspections must utilize the appropriate BIM report developed for each bridge on the Provincial road network.
2. The bridge inspector is responsible to verify and update the inventory information noted on the BIM inspection report. Responsibilities and procedures for updating inventory information is outlined in the “Bridge Information System (BIS) for Inspection Consultants User Guide”.

3. All bridge elements with a condition rating of 3 or less must be supplemented with an explanation of condition, photographs and/or sketches and a maintenance recommendation.
4. All bridge elements which are critical to the safe operation of the bridge and are rated 2 or less must be reported immediately to the Bridge Manager. In addition, if the bridge is the responsibility of a Local Road Authority, the low rating must also be reported to the Local Road Authority. The inspector must record the name(s) of who was notified and the date of notification in the 'Special Comments for Next Inspection' section.
5. All deficiencies with bridge related signs must be reported to the Bridge Manager.
6. All Level 1 bridge inspection forms including those done by the Technical Standards Branch - Bridge Engineering and any other agencies must be submitted to the Bridge Manager, or the Consultant delegated by the Department, for review and data entry.
7. Forms from specialized inspections must be submitted to the area in Technical Standards Branch - Bridge Engineering that is responsible for management of the auxiliary data module. A copy of the report and associated photographs must be forwarded to the Bridge Manager.

3. CHAPTER 3 - INSPECTION PREPARATION, EQUIPMENT & SAFETY

3.1. PREPARATION FOR INSPECTION

Careful preparation and planning are essential for complete, efficient and safe inspection of bridge structures.

3.1.1. Scheduling

A summary report of the bridge structures to be inspected within a certain period of time should be requested from the BIM system. The system can generate forms that are sorted using various options such as geographical areas, highway number or type, bridge categories, etc. to help simplify planning the sequence of inspection.

If bridge file maps are not available, plot the sites to be inspected on appropriate maps such as County maps and topographical maps. Review the locations of the bridge sites and plan the sequence of inspection so as to minimize traveling time.

Order the BIM forms and arrange them to match the sequence of inspection.

3.1.2. Structure Background

Inspectors should familiarize themselves with the structures to be inspected. Background information on every structure can be obtained from the following sources:

a) BIM forms which should be reviewed for inventory information as well as information noted during the last inspection especially ‘Special Comments For Next Inspection’, ‘Maintenance Recommendations’, and ‘Explanation of Condition’
b) bridge correspondence files which usually contain historical information and maintenance records
c) design and/or as-constructed drawings
d) other reports such as those containing traffic data and hydrologic records

Review the correspondence files for specific concerns or requests from other agencies. In many cases these concerns or requests can be assessed during the inspection. Also, joint inspections with others can be handled at the same time.

3.1.3. Manpower

The manpower requirements for field inspection depends on factors such as the type and size of structure, location of structure, traffic volumes and type, and anticipated weather conditions during the inspection. The inspector(s) must be in good physical health and possess a working knowledge of the standard equipment required for inspection. Also, they must have good communication skills and respect for safety rules and regulations to protect themselves and others.

3.1.4. Equipment

The inspector is expected to have a complete set of standard equipment (see section 3.2) onsite during inspection. The equipment must be checked prior to the inspection to ensure it is in good working condition and is adequate for the types of bridges to be inspected. Special personal equipment may be required depending on the weather conditions. Checking the weather forecast before leaving for the inspection trip is always a good idea.

3.2. EQUIPMENT

3.2.1. Standard Equipment (Level 1 and Level 2 Inspections)

This section deals with equipment required to undertake Level 1 and Level 2 inspections.

Each inspection team or inspector, is required to have a complete set of standard equipment (see Table 3.1) while on site. All equipment should be of good quality and in good working condition.

ITEMS		USES
1.	BIM reports, Field books, Clipboard, Pens/pencils, & Industrial crayons	Recording inspection information
2.	Cloth tape (30 m) & Steel Weight	Measuring large dimensions such as bridge height, depth of scour, roadway width
3.	Measuring tape (5 m)	Measuring dimensions of bridge components, defects, etc.
4.	Chipping hammer	Checking soundness of timber and concrete, removing deteriorated concrete, paint, and rust build up, etc.
5.	Metal scraper/wire brush	Removing encrustations, deteriorated paint and light corrosion
6.	Pocket knife/Ice pick	Checking rot in timber, deterioration in paint, and concrete, etc.
7.	Flashlight	Inspecting darkened areas
8.	Inspection mirror	Inspecting areas that are not readily visible
9.	Binoculars	Inspecting areas that are too far away to be seen clearly
10.	Camera with suitable lenses and flashes	Documenting deterioration, damage, and deficiencies.
11.	Hand level	Determining vertical alignments, sideslopes, etc.
12.	Plumb bob	Determining amount of tilt, lean, or out of plumb
13.	Range finder (40 m)	Estimating distances
14.	Thermometers	Measuring air temperature while inspecting bearings and expansion joints
15.	Personal Equipment (hard hats, vest, boots, rain gear, safety belts, extra clothes, etc.)	Personal comfort and safety

ITEMS	USES
16. Digital measuring rod	Determining vertical and horizontal dimensions
17. Crack Width Gauge or Piano Wire	Determining crack widths or depths in concrete, steel and other members
18. Compass	Determining directions

Table 3.1 - Standard Equipment for Level 1 Inspections

ITEMS	USES
1. Increment borer	Taking test cores to determine degree of internal rot
2. Cordless power drill	Determining the presence of internal rot
3. Creosote timber plugs, steel pins, or lag bolts	Plugging holes made by increment borer and/or drill

Table 3.2 - Additional Equipment For Level 2 Inspection of Timber Bridges

ITEMS	USES
1. Steel punch	Marking the ends of cracks
2. Magnifying glass	Checking areas suspected of cracks
3. Dye penetrant	Detecting surface cracks and defects

Table 3.3 - Additional Equipment for Level 2 Inspection of Steel Bridges

ITEMS	USES
1. Tape recorder	Recording information especially in adverse conditions
2. Ladder	Accessing areas not normally accessible from the ground
3. Dry film paint gauge	Measuring paint coating thickness
4. Signs and other equipment for traffic control	Reducing chances of accidents

Table 3.4 - Optional Equipment

3.3. SAFETY CONSIDERATIONS

The bridge inspector and all members of his crew must employ safe working practices to minimize accidents that could affect themselves, other crew members and the traveling public.

3.3.1. General Precautions

- The bridge inspector and all members of his crew are governed by the Province of Alberta Occupational Health and Safety Act & pursuant Regulations, and Department policies.
- The routine nature of the inspection tasks is conducive to accidents and as such everyone must be alert at all times.
- Avoid taking unnecessary risk.
- Use proper equipment for personal and team safety.
- Equipment should be in good working condition and of good quality.
- Operation of equipment should be in accordance with the manufacturer's specifications.
- Keep working area free from ice, dirt, debris, unnecessary equipment and tools, etc.
- Assume all electrical equipment and facilities are "live".
- Be aware of problems and limitations when wearing bifocals during inspections.
- Do not enter confined spaces that may constitute a health hazard.
- Use caution when walking or working on ice sheets; they are slippery and may break suddenly.
- Inspectors should have communication equipment available, know how to use it and should also know the appropriate emergency phone numbers for the area they are working in.
- Inspectors should notify someone of their inspection plans including the area and sites to be inspected and their anticipated time of return.

3.3.2. Use of Equipment

Many accidents and injuries are caused by the improper use of equipment, use of the wrong equipment for the job, and/or failure to wear appropriate personal safety equipment.

The following safety precautions must be followed when using this equipment:

- **Portable Ladder:** Extension ladder must be equipped with locks and the overlap must meet the manufacturer's specifications or in the absence of the manufacturer's specifications, use at least 1 metre. Do not work from the top two rungs. Locate ladder so that the base is firm and will not slip. Do not place metal ladders against electrical equipment and facilities.
- **Scaffolding:** The base should be properly anchored. The scaffold should be designed to support at least four times the load that may be imposed on it. All components of the scaffold should be inspected daily.
- **Standard Equipment:** This equipment must be kept in a condition that will not compromise the safety of workers using or transporting them. Equipment should be used to perform functions for which they are intended or were designed.

- **Snooper:** As with other equipment, the snooper must be checked daily prior to use. The operator must follow the manufacturer's instructions and advise the inspection crew about the hazards associated with its operation. Traffic control is required whenever the snooper is located on the bridge.
- **Safety Harness:** They should be properly adjusted to fit securely and attached to a fixed anchor or a life-line. They must also be checked carefully prior to use.

3.3.3. Traffic Safety

The inspector(s) must maintain strict safety practices and be alert at all times when working on the bridge deck. The following practices should be followed:

- Schedule inspection during hours of low traffic flow and high visibility.
- Inform local road authority of proposed traffic interruptions when traffic lanes are to be closed.
- Park vehicles off the roadway and use warning lights if necessary.
- Inspectors must wear high visibility vests.
- Inspectors and equipment should be restricted to the protected area.

3.4. PERSONAL PROTECTIVE EQUIPMENT

The following list of personal equipment is recommended:

- Hard hat with chin strap to minimize the danger of head injury.
- Work boots with non-slip soles for protection and stability.
- Extreme caution is required when using hip waders for inspecting culvert barrels. Inspectors must **not** use chest waders for safety reasons.
- Gloves and warm clothing for inspection during winter months.
- Rain gear for inspection during rainy seasons.
- Life jackets when engaging in inspection where a fall could result in drowning.
- Eye protection when performing tasks that may cause flying debris.
- Safety harnesses and lanyard for use as required by Occupational Health and Safety regulations.

4. CHAPTER 4 - GENERAL INSPECTION FORM INFORMATION

Inventory data and other general information is extracted from the TIMS system and printed on the inspection form. This chapter describes the inventory data and other information that applies to all bridge and culvert inspection forms. Other inventory data that applies to particular bridge types or components (e.g. deck joints) are described in the chapter where the particular bridge type or component is discussed.

4.1. INVENTORY DATA

This information appears on the upper left hand corner of the first page of the inspection form.

4.1.1. Bridge File Number

The Bridge File number field will show the bridge file number, followed by the visual identifier, followed by the structure number, followed by a text descriptor (e.g. 75223E 1 Bridge).

4.1.1.1. Bridge File Number

This is a five-digit number, which identifies a specific bridge site. The possible ranges are:

00101	to 02499
06500	to 09999
13000	to 13999
70000	to 99999

4.1.1.2. Visual Identifier

There may be more than one structure at a bridge site. Each structure may have associated with it a business visual identifier of up to three characters, which may indicate the direction of traffic and/or the type of structure (e.g. sign structure). The inspector will use the bridge file number and the visual identifier to determine the structure that is being inspected.

4.1.1.3. Structure Number

The Department's Transportation Infrastructure Management System (TIMS) assigns each structure at a bridge site a unique structure number starting with 1 and incremented by 1 for each subsequent structure at the site. If a structure at a site is replaced or a structure is added, the new structure is given a new number.

4.1.1.4. Text Descriptor

This describes the type of structure. Possible structure types are:

- Bridge
- Bridge Culvert
- Ferry
- Low Level Crossing
- Sign Structure
- Water Course Training Structure

4.1.1.5. Bridge Plaques

All major bridges will have a bridge plaque showing the bridge file information at each end of the structure. Standard bridges will usually have a smaller plaque or tag, with the file number. The plaques or tags are normally located on the abutment wingwall or attached to the abutment cap. Some culverts have a metal tag attached to each end of the culvert. The bridge plaque on new structures will have the file number and structure number on them. However, existing structures may only have the file number and visual identification or, depending on the age, they may only have the file number.

4.1.2. Year Built

This field will contain two dates for bridges and one date for culverts. For bridge structures the first date is the year the bridge or the substructure was constructed at this site. The second date is the year in which the superstructure was fabricated. For culverts the date is the year the original barrel section was constructed at this site.

4.1.3. Bridge Or Town Name

The precedence for naming is in the following order: structures with an established name, nearest well known towns or lesser known towns that are shown on the Alberta road map, and the nearest post office.

4.1.4. Located Over

This is the name of the stream/facility being crossed. Unnamed streams are called watercourse or tributaries to other streams/rivers. There is additional information following the stream/facility name that is used by others and can be disregarded by the inspector. For grade separations, ‘Located Over’ indicates the facility crossed (i.e. name of highway or railroad).

4.1.5. Located On

This indicates the roadway crossing the structure. The roadway may be a Provincial Highway, local road, railroad or trail.

For Provincial Highways there will be a highway number and a control section. The control section identifies a specific section of a numbered highway. If two control sections meet at the middle of the structure, then the structure will be coded with the higher control section number. There is additional information following the highway control section number that is used by others and can be disregarded by the inspector.

4.1.6. Water Body Class/Year

This is a new field on the inspection forms which indicates the water body class of the watercourse. This information is maintained by Alberta Environment and may change from time to time. The year will be the year of the classification or year of any changes or updates.

4.1.7. Navigability Class/Year

This is a new field on the inspection forms which indicates the navigability class of the watercourse. The classification field may be blank or consist of two alphanumeric characters and a year of the classification or the year of any changes or updates.

4.1.8. Legal Land Location

This consists of the following (see Figure 4.1):

a) Quarter Section designation (NE)
b) Section Number (1 to 36)
c) Township Number (1 to 126)
d) Range Number (1 to 30)
e) the Meridian east of the site (4 to 6)

For example: NE SEC 25 TWP 28 RGE 3 W5M

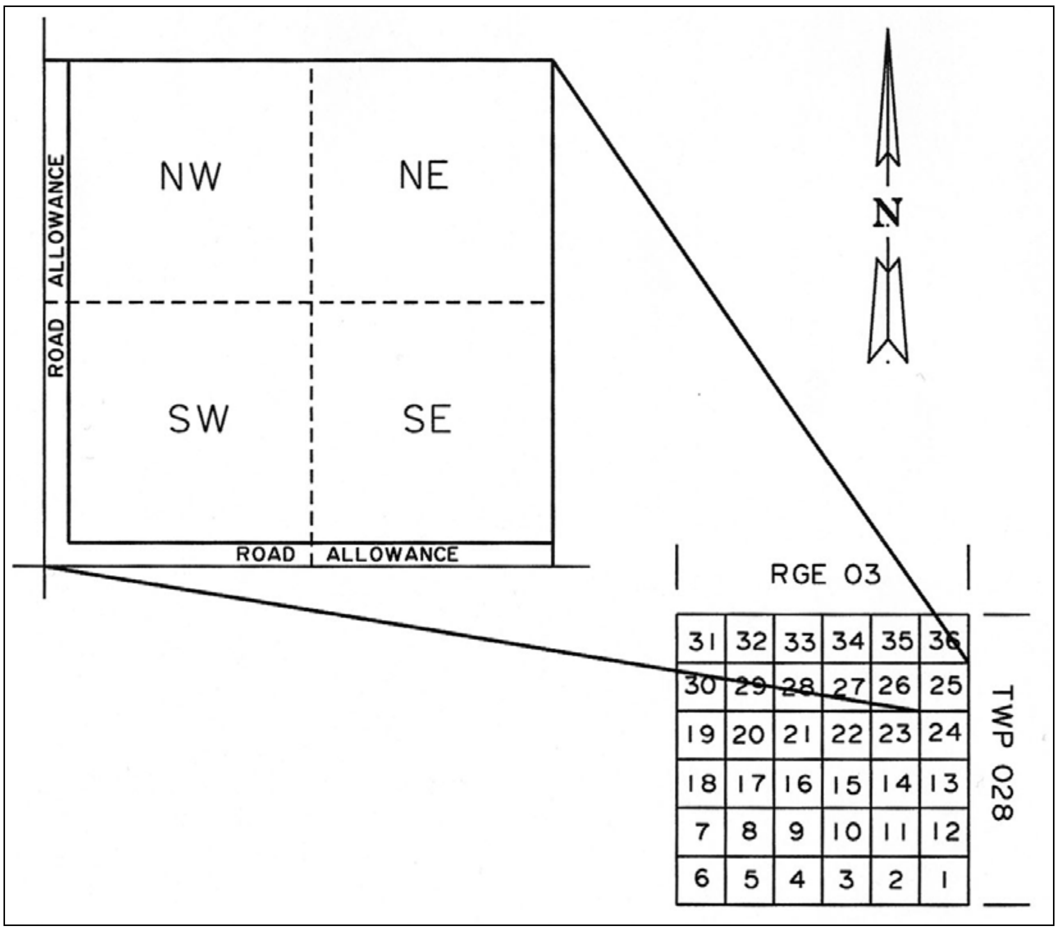


Figure 4.1 - Legal Land Location

4.1.9. Longitude/Latitude

This is a field for the longitude and latitude co-ordinates of the bridge structure.

4.1.10. Road Authority

This describes the road authority (Department or Municipal Authority), which has geographical jurisdiction of the site. The Department is responsible for all Provincial High ways, Forestry Roads, all Approach Roads, all roads in Improvement Districts, and all other roads the Minister of the Department agreed to manage on behalf of a Municipal Authority. The Municipal Authorities include Counties, Municipal Districts, Special Areas (Minister of Municipal Affairs), Alberta Environment, Irrigation Districts, Cities, Towns and Villages.

For crossings located on streams which form the boundary between road authorities, the responsible road authority for the crossing is the road authority to the left when looking downstream.

4.1.11. Contract Maintenance Area

For bridges on Provincial Highways, this is the Contract Maintenance Area (CMA) in which the bridge is located.

4.1.12. Clear Roadway/Skew

This refers to the clear roadway on a bridge or over a culvert and is measured to the nearest 0.1 metre. For bridges, it is the distance between the inner faces of the curbs measured perpendicular to the center line of the structure or in the absence of curbs, the distance between the inside of the bridgerails. For culverts, the clear roadway is the width of the road over the culvert between the edges of shoulders. For tapered roadways, the minimum width is used. For structures with medians, it is the total clear width of all the lanes.

The skew is the angle that the centerline of piers and abutments make with a line perpendicular to the centerline of the roadway. The angle is shown in degrees and is noted as a positive value for right hand forward skews and a negative value for left hand forward skews.

4.1.13. AADT / Year

This field consists or three parts. The first part is the traffic count, the second part is the year in which the traffic count was obtained and the third part is a letter indicating an actual traffic count (A) or an estimate (E) (e.g. 5,000/2004 (A)).

Actual traffic counts are taken on Provincial Highways and where actual traffic counts are shown on the form, the inspector should not change these numbers.

Actual traffic counts are not taken on local road structures and the inspector should record an estimate during each inspection, based either on site experience or the Hourly Conversion Factors for Local Roads. Table 4.1 can be used to estimate the traffic count at a particular location. To estimate the traffic count, the number of vehicles that pass over the structure for a known time period is counted. This number is prorated to one hour and then multiplied by the appropriate factor from the table.

AADT Hourly Conversion Factors for Local Roads – 1988									
	Hour Ending								
Month	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
January	21.81	20.42	19.26	18.46	19.59	16.84	18.11	15.00	14.33
February	21.79	20.24	16.66	17.34	18.88	16.66	16.03	13.49	13.28
March	20.24	18.47	17.34	17.34	18.08	15.45	15.45	13.93	12.68
April	19.31	17.34	16.34	17.80	17.34	15.17	15.17	13.70	12.88
May	15.45	16.03	15.45	16.03	16.03	14.46	13.93	12.32	12.14
June	16.34	15.74	14.65	14.65	16.03	13.93	14.16	12.50	11.97
July	20.73	17.34	16.03	16.03	17.00	14.91	14.65	14.40	13.07
August	20.73	17.34	14.91	14.91	16.03	13.28	13.28	13.07	11.97
September	19.31	18.47	16.66	16.66	17.34	15.17	14.65	13.93	13.07
October	15.33	13.80	15.33	14.68	15.00	13.53	13.26	11.69	11.50
November	20.29	18.15	16.04	16.42	16.82	15.33	14.68	13.52	12.77
December	23.79	19.71	15.68	15.68	16.82	14.37	14.37	14.08	13.26

Table 4.1 - AADT Conversion Table

Example:

In the month of March, 12 vehicles are counted passing over a structure in a half hour time period between 1 and 2 o'clock in the afternoon (hour 13 to hour 14).

Estimated count = (number of vehicle/hours)*factor
= (12/.5)*15.45
= 371

4.1.14. Road Classifications

All public rural roads in the Province have a road classification. Table 4.2 shows some of the classifications currently used by the Department.

Road Type	Road Standard
Local Roads (Gravel)	RLU-207G-060 RLU-208G-060 RLU-208G-090 RLU-209G-090 RLU-210G-090
Local Roads (Paved)	RLU-208-100 RLU-208-110
Provincial Highways (Gravel)	RCU-208G-090 RCU-209G-090
Provincial Highways (Paved)	RCU-208-110 RCU-209-110 RCU 210-110 RAU-209-110 RAU-210-110 RAU-211.8-110 RAU-213.4-110 RAU-213.4-120
Provincial Highways (Divided)	RAD-412.4-120 RAD-616.6-130 RFD-412.4-130 RFD-616.6-130

Table 4.2 - Road Classifications

The first letter 'R', is an abbreviation for Rural. The second letter 'L', 'C', 'A', or 'F', is an abbreviation for local, collector, arterial, or freeway, respectively. The third letter 'U' or 'D' is an abbreviation for undivided or divided, respectively. The first numerical digit indicates the number of lanes. The second and third numerical digits (also fourth for RAD, RAU and RFD), indicate the sum of the lane and shoulder width in metres. The last three digits indicate the design speed in kilometres per hour.

The following example describes the various components of a typical road classification.

RLU 209G-90

- the letter R indicates that the road is in a rural area
- the letter L indicates that the type of road is local
- the letter U indicates that the road is undivided
- the number 2 indicates there are two lanes on the road
- the number 09 indicates the roadway width is 9 metres including the shoulder widths
- the letter G indicates that the road is graveled
- the number 90 indicates the design speed for the road is 90 kilometres per hour

The inspector is to verify the road classification and provide corrections when errors are found. If the road classification is not shown on the form, assign one from the table. The table lists the road classifications currently in use by the Department.

The majority (95%) of gravel local roads fall under the RLU-208G-090 classification. The 60 km classification is only used for special cases where the speed is reduced (i.e. towns, villages, urban settings, etc.).

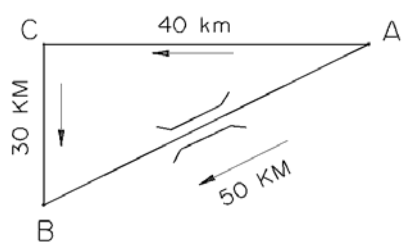
4.1.15. Detour Length

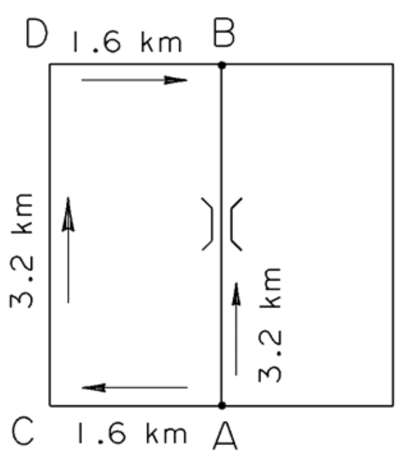
This is a field that ranges from 0 to 999.

Detour length is defined as the minimum extra distance to be traveled if the bridge on the intended route is removed or closed. The detour bridge is the nearest bridge on the same stream that has the same or greater load capacity (or one that can be temporarily strengthened on short notice). The detour roadway should also be of similar geometry, quality and be capable of carrying the vehicle weights and volumes. The detour length is recorded to the nearest kilometre.

The detour length applies to the general overall flow of vehicles and is determined from the intersections on the detour route and the original route. The recorded detour length does not apply to the individual that resides next to the bridge and is required to backtrack.

The following examples illustrate how the detour length is determined.

<table>
<tr>
<td>
</td>
<td>The distance from point A to B is 50 km. If the bridge is closed or removed, the detour route is from point A to C to B which covers a distance of 70 km (40+30).

Detour length = 70 - 50 = 20 km</td>
</tr>
<tr>
<td>
</td>
<td>The distance from point A to B is 3.2 km. If the bridge is closed or removed the detour route is from A to C to D to B which covers a distance of 6.4 km (1.6+3.2+1.6).

Detour length = 6.4 - 3.2 = 3.2 km

Record detour length as 3 km</td>
</tr>
</table>

Table 4.3 - Detour Lengths

Exception detour lengths for some specific situations are:

- bridges on roads with four or more lanes, the detour length is 0 km
- bridges on divided highways, the detour length is 1 km
- bridge on a dead end route, the detour length is recorded as 999 km

4.2. GENERAL INFORMATION

This information appears on the upper right hand corner of the first page of the inspection form.

4.2.1. Lot Number

A lot number is assigned to each completed inspection report by the Reviewer in accordance with the following criteria:

- Lot 1 reports for structures requiring major repairs, a Level 2 inspection, reduced inspection cycle or an engineering assessment
- Lot 2 reports for structures requiring minor or routine repairs
- Lot 3 reports for municipal structures requiring minor repairs not funded by the Department
- Lot 4 reports for structures requiring no action or monitoring

4.2.2. Inspector Name and Class

Name of the inspector that completed the inspection and inspector's Class (A or B).

4.2.3. Assistant Name and Class

Name and class of assistant inspector if applicable.

4.2.4. Inspection Date

Date inspection was completed. Use format of day, month, year (e.g. 26-Sep-2005).

4.2.5. Data Entry Date

Date that inspection data was entered into system. Use format of day, month, year (e.g. 26-Sep-2005).

4.2.6. Reviewer Name/Review Date

Name of person that completed the review of the inspection report and the date review completed.

4.2.7. Department's Reviewer Name/Department Review Date

Name of Department staff that completed the review of the inspection report and the date review completed.

4.2.8. Follow-up By

Department staff member or area that is required to complete follow-up action, if applicable.

5. CHAPTER 5 - POSTING INFORMATION & UTILITIES FOR BRIDGES

The ‘Required Vert. Clearance Posting’ and ‘Required Load Posting’ information is extracted from TIMS (if available) and printed on the inspection form.

All other information on this section of the form is entered into the computer after the first inspection. For subsequent inspections, the BIM report will be printed with this information. During each inspection the inspector is expected to verify that this information is current. All discrepancies should be noted for updating the system.

5.1. POSTED VERTICAL CLEARANCE

Required Vert. Clearance Posting (m)											
Posted Vertical Clearance (Y/N)											
Posted	Lane		On bridge (m)		In Advance (Y/N)		Lane		On Bridge (m)		In Advance (Y/N)	
Remarks											

5.1.1. Background

This section only appears on the BIM report when the form ID contains TH (Through Truss), or the structure usage is either GS (Grade Separation), PS (Pedestrian Grade Separation), RO (Railroad Overpass), or RU (Railroad Underpass).

The posted vertical clearance for an individual structure is the minimum measured height between the lowest point of the structure and the surface of the clear roadway, less 0.1 metre tolerance, and rounded down to the nearest 0.1 metre. This height is posted on the structure at the midway point over the driving lanes, with one sign for each direction of travel. In situations where there are multiple structures, or a series of structures without access roads between them, only the minimum vertical clearance of these structures is posted. Also, advance warning signs indicating the vertical clearance are posted in each direction of travel.

The legal vehicle height without permit in the Province is 4.15 metres. New grade separation structures are designed to provide a minimum of 5.35 metre clearance.

5.1.2. Inspection and Coding Procedures

- The bridge inspector should check all signs posted in advance, and at the bridge in both directions of travel.
- Look for evidence of reduced vertical clearance due to new wearing surface or gravel buildup. If there is evidence that a reduction in the vertical clearance may have occurred since the last inspection, notify the Bridge Manager to confirm the vertical clearance.
- All signs should be legible and visible to the road user.
- All signs referring to the same opening must indicate the same vertical clearance.

- The inspector enters or verifies (Y/N) if vertical clearance signs are posted on bridge.
- The inspector enters or verifies the direction of travel (e.g. E for East bound, N for North bound, etc.), and the corresponding vertical clearance noted on the signs at the bridge for each direction of travel. The clearance noted on the signs should be the same as shown in ‘Required Vert. Clearance Posting’ field.
- The inspector enters or verifies (Y/N) the presence of advance warning signs for each direction.
- Location of all missing signs should be noted in the remarks field.
- The inspector should notify the road authority that is responsible for the bridge in the cases of:
  a) missing signs
  b) illegible signs
  c) poorly visible signs
  d) signs which require relocation, repair, or replacement
  e) clearance on sign not the same as ‘Required Vert. Clearance Posting’

5.2. POSTED LOADING

Required Load Posting (tonnes)			Single		Semi		Truck Train	
Posted Loading (tonnes)			Single		Semi		Truck Train	
Posted	Lane		At Junction (Y/N)		Advance (Y/N)		At Bridge (Y/N	
Posted	Lane		At Junction (Y/N)		Advance (Y/N)		At Bridge (Y/N	
Remarks:								

5.2.1. Background

Allowable Load/Design Load

This is the allowable load of the bridge shown as the gross weight in tonnes to the nearest 0.1 tonne for the three types of truck configurations: the single unit truck configuration (H or CS1), the semi-trailer truck configuration (HS or CS2) and the truck train configuration (CS3). These allowable loads are automatically retrieved from the Bridge Rating Information System (BRIS) module in TIMS which determines the critical rating for the bridge based on span rating information. The corresponding critical member is also noted for each of the truck configurations.

The design loading, if available, is printed on the form when the rated allowable load is not available. This value is printed as one of the H, HS, MS, or CS configurations.

Legal Loads

Legal loads are the gross vehicle weights in tonnes that are allowed by legislation on the different roadway systems. Bridges on the public road systems are posted if the allowable loads are less than the legal loads.

The current legal loads are:

Truck Type		Local Roads	Provincial Highways
Single	(CS1)	28 tonnes	28 tonnes
Semi	(CS2)	49 tonnes	49 tonnes
Truck Train	(CS3)	54 tonnes	63.5 tonnes

5.2.2. Inspection and Coding Procedures

- If there are numbers entered in the 'Required Load Posting' field, the bridge should be posted to those numbers.
- If there is no entry in the 'Required Load Posting' field, check the allowable or design loading noted on the first page of the BIM report. If these loadings are below the legal limits, then the bridge should be posted.
- The bridge inspector must check all load posting signs at the bridge, in advance of the bridge and at the nearest intersection in both directions of travel.
- In general, bridges requiring posted load signs should have signs placed as per drawing TEB 1.28. However, in some situations, three signs on each side may not be required.
- All signs must show the same loadings.
- The inspector should note the loads shown on the signs for the three types of truck configurations (see Figure 5.1).
- Legal truck loads are allowed on some bridges if only one truck at a time is on the structure. These bridges will have 'One Truck' posting signs at the bridge (see Figure 5.2). In these cases the inspector should note the existence of these signs in the remarks field.
- All load posting signs should be legible and visible to the user.
- Missing signs, both in advance and at the bridge, should be noted.
- The bridge inspector should contact the Bridge Manager if load posting signs are missing or are incorrect.

The inspector should notify the responsible road authority of the bridge in cases of:

a) illegible signs
b) poorly visible signs
c) signs which require repair or replacement

Figure 5.1 - Standard Load Posting

Figure 5.2 - One Truck Sign

5.3. HAZARD MARKERS

Hazard Marker at Bridge (Y/N)	
Remarks	

5.3.1. Background

The present practice is to install hazard markers on all four corners of a bridge when the width of the approach roads is greater than the clear roadway of the bridge, on all standard bridges located on local roads, and at low level crossings. The hazard markers are installed with the black stripes slanted downwards, toward the roadway surface. In the case of a one-way bridge, hazard markers are not required at the exiting end.

5.3.2. Inspection and Coding Procedures

- Determine if hazard markers exist on all corners of the bridge. If there are no hazard markers, enter N. If any of the hazard markers are missing note the location of missing markers in the remarks field.
- If hazard markers are not installed because they are not required, enter N and write 'not required' in the remarks field.
- Determine if all hazard markers are properly installed and if they are in reasonable condition.
- The inspector should note if the hazard markers are at the correct location (installed in line with railing posts) and height (bottom of sign 1200 mm above the wearing surface).
- The inspector should notify the road authority that is responsible for the bridge when there are missing, illegible, poorly visible signs, or signs which require repair or replacement.

5.4. OTHER SIGNS

Other Sign Types	

5.4.1. Background

Other bridge signs include signs both on the bridge and within the sight distance of the approaches to the bridge. Examples of these signs are 'Narrow Bridge', 'Speed Limit', 'Sharp Bends', 'Slippery When Wet', etc.

5.4.2. Inspection and Coding Procedures

- Inspect the condition of all other signs, as well as their legibility and visibility from a driver point of view.
- Record the type of sign, and note its location and condition on the remarks line.

5.5. UTILITIES

Telephone		Gas	
Power		Municipal	
Others		Problems (Y/N)	
Remarks			

5.5.1. Background

The owner of the utility is responsible for its inspection, maintenance, and operation. The bridge inspector is not required to provide a condition rating for each utility that is attached to the bridge, or located within the right-of-way adjacent to the bridge. However, the bridge inspector must check all utilities since they may:

a) overload the bridge
b) interfere with routine maintenance
c) create a hazard to the traveling public and the bridge
d) present an objectionable or unacceptable appearance

The Department discourages the installation of utilities on bridges. The owner must obtain approval from the Bridge Manager before permanent installation of any utility on bridges. The application must be accompanied with engineering drawings showing the details, proposed location, and method of installation of the utility.

The following methods of attachment are not permitted, and if present, should be noted as problems on the BIM report:

- drilling into prestressed girder legs
- explosive driven attachments to both concrete or steel
- welding on or drilling into steel members
- drilling larger than required holes in timber components or failure to treat and/or plug the holes

The following information will help to locate and/or determine the proper locations for utilities on structures:

- **Newer Concrete or Steel Girder Bridges**: A continuous conduit is typically provided for utilities such as telephone, power or fibre optic in both curbs. Other utilities may be located between the legs of the girders (if present) and attached using clamps on the underside of the deck and the diaphragms.
- **Precast Concrete Bridges**: The utilities may be attached to the side of the curb units using "U" straps. Where timber hand rail posts are present, the utility may be attached to posts.
- **Standard Prestressed Bridges**: The utilities are located in the outside void of the curb unit for all 'VS' type girders built after 1976 and all SM and SC girders.
- **Truss Bridges**: The utilities are typically located on an outward projection or are clamped to the bottom chord.

5.5.2. Inspection and Coding Procedures

- Note the location of each utility (i.e. 2 wire OH; S. of CL).
- Look for excessive sagging of the cable or conduit that may cause cracks or leaks, and/or may reduce vertical clearance or freeboard.
- Look for signs of damage, corrosion, and loose connections on the utility and its supports.
- Look for improper methods of attaching utilities to the bridge.
- Check for evidence of leaks on water or sewer pipes. Leaks may cause serious problems to the bridge, as well as slippery conditions to roads below.
- Note any utility that may interfere with routine maintenance.
- Expansion joints on the utility should be functional. The distances between fixed and expansion joints should approximately match those on the bridge (except standard concrete or timber bridges).
- Municipal utilities may include water and sewer.
- Note the locations of all utilities, such as power poles, etc., found at the bridge site.
- Check the connections of utilities at locations such as abutments, where settlement is likely to occur.
- Check the utility and its support to ensure they do not affect the structural integrity or aesthetic appearance of the bridge.
- Utilities with any problems which create a hazard to the public or the structure should be recorded on the BIM report and reported as soon as possible to the Bridge Manager.

6. CHAPTER 6 - APPROACH ROADS

6.1. INTRODUCTION

Bridge structures are relatively short and expensive sections of the road and in some situations may have considerable influence on the level of service and safety to the public. It is desirable that the bridge geometrics be compatible with the approach roads. All major rehabilitation or proposed replacement should include an evaluation of the approaches.

Previously, the vertical and horizontal alignments of the approach road were rated relative to the minimum desirable current standards. These elements are now rated relative to acceptable condition and functionality similar to the rating of most other bridge elements.

A simple procedure to determine if the alignment is functional is to look for signs related to operating safety such as speed limit signs or sharp curve signs. If signs are not found, drive over the bridge at the speed limit if road conditions permit and rate accordingly. The existing clear roadway should not influence the vertical or horizontal alignment ratings unless a narrow roadway width requires a speed reduction.

The length of the approach road to be evaluated by the bridge inspector is 1 km measured from the end of the bridge. The evaluation of the approaches should begin as the inspector drives towards the bridge. Information to be noted includes signs, obstructions, horizontal and vertical alignments, roadway width, guardrails, bump at bridge ends, embankment, stability, drainage in vicinity of the bridge, access roads, etc.

The presence of intersections near the bridge site may have a downward effect on the alignment rating. Steep grades, vertical curves or horizontal curves may reduce sight distances for vehicles on the roadway and those turning onto the roadway. The presence of intersecting roads or other such features must be described in the 'Explanation of Condition' even if the alignment rating is not affected.

6.2. HORIZONTAL ALIGNMENT

Component	Last	Now	Explanation of Condition
Horizontal Alignment			

6.2.1. Background

This element refers to the horizontal alignment of the road in both directions from the bridge.

6.2.2. Inspection and Coding Procedures

- Look for speed limit signs or signs indicating sharp curves ahead.
- If signs are not present, drive at the legal speed limit if road conditions permit.
- Check for all obstructions and intersecting access roads and record location on inspection form.
- Consider the combined effects of the horizontal and vertical alignments.

- Observe if super-elevation and/or tangent runout is on the bridge.
- Check for proper transition from the road to single-lane bridges.
- Check for adequate sight distances for passing and stopping.

6.2.3. Rating Guidelines

- If bridge is on tangent that extends a minimum of 1 km from each end, rate 9.
- If there is an intersection or access road entering the roadway, rate 7 or less.
- Field accesses should not reduce horizontal alignment rating.
- If the approach road can be safely driven at the legal speed limit, rate 6 or better.
- If the approach road is posted no more than 20 km/hr below the legal speed limit because of horizontal alignment and can be safely driven at the posted limit, rate 5.
- If the approach road is posted more than 20 km/hr below the legal speed limit because of the horizontal alignment and can be safely driven at the posted limit, rate 4 or less.
- If there are site conditions that have a negative affect on the horizontal alignment (e.g. sharp or blind horizontal curves), rate 4 or less.
- For land access bridges (structures carrying minimal traffic volumes to service only land and not residents) these rating guidelines do not apply. If all appropriate warning signs are in place, rate 5.

6.3. VERTICAL ALIGNMENT

Component	Last	Now	Explanation of Condition
Vertical Alignment			

6.3.1. Background

This element refers to the vertical alignment of the road that ties onto the bridge deck from both ends of the bridge.

6.3.2. Inspection and Coding Procedures

- Look for speed limit signs or signs showing steep grade ahead.
- Drive the legal speed limit if the road conditions permit and warning signs are not posted.
- Check for access roads and consider the effect of the traffic generated.
- Consider the combined effects of the horizontal and vertical alignments.
- Determine if the bridge is on a sag curve, crest curve, or grade.
- Check for adequate sight distances for stopping and passing.

6.3.3. Rating Guidelines

- If the approach road is on a grade of 1% or less, rate 9.
- If the approach road can be safely driven at the legal speed limit, rate 6 or better.
- If the approach road is posted not more than 20 km/hr below the legal speed limit because of vertical alignment and can be safely driven at the posted limit, rate 5.
- If the approach road is posted more than 20 km/hr below the legal speed limit because of the vertical alignment and can be safely driven at the posted limit, rate 4 or less.
- If there are site conditions that have a negative affect on the vertical alignment (e.g. steep grade, blind crest curves), rate 4 or less.
- For land access bridges (structures carrying minimal traffic volumes to service only land and not residents) these rating guidelines do not apply. If all appropriate warning signs are in place, rate 5.
- If the combined effects of horizontal and vertical alignment cause a hazardous situation, rate 2.

6.4. ROADWAY WIDTH

Component		Last	Now	Explanation of Condition
Roadway Width (m)				

6.4.1. Background

The roadway width refers to the width of the approach road, which consists of the travel lanes and the shoulders. To be included, the shoulders located adjacent to the travel lanes must be structurally adequate for all weather and traffic conditions. The transition or rounding between the outside edge of the shoulder and the sideslope is not included.

This element is one of the inventory items used to calculate the bridge sufficiency rating. A condition rating is not required. Once the information is entered into the computer, it will appear on all subsequent BIM reports for the bridge.

6.4.2. Inspection and Coding Procedures

- The approach roadway width is measured at a location that best represents the overall width of the road without being affected by guardrail, etc.
- All measurements are made perpendicular to the centerline of the road, to the nearest 0.1 metre.
- For approaches with curbs, the measurement is made between the inner faces of the curbs.
- For approaches with medians, the measurement is the total clear width of all the travel lanes and shoulders.
- The minimum width measured on either approach is recorded and the location is noted in the ‘Explanation of Condition’ column.

6.5. APPROACH BUMP

Component	Last	Now	Explanation of Condition
Approach Bump			

6.5.1. Background

This item is rated to indicate the degree of settlement or unevenness of the approach fills adjacent to the bridge ends and its effect on the traveling public. This transition area could be embankment material, gravel surface, asphalt pavement, or concrete approach slab.

6.5.2. Inspection and Coding Procedures

- Check the severity of the bump by driving over the transition at both ends of the bridge at the speed limit or lower safe speed.
- Observe noise level, impact, and vibration force on the bridge caused by passage of vehicles.
- Look for cracks or damage to approach slabs.
- Determine the cause of the bump by checking for settlement and stability of the embankment adjacent to the bridge, and for loss of embankment material from under abutment sheathing or defective wingwalls.

6.5.3. Rating Guidelines

- A smooth transition with no surface cracks or settlement at the bridge ends, rate 9.
- A bump that is noticeable, but tolerable, rate 5. If the driver has to reduce speed, rate 4 or less.
- A rating of 2 or less is necessary when the bump constitutes a safety hazard to the public. For example, partial washout next to the abutment, loss of control when pulling trailers, and damage to vehicle under-carriage. Immediate action is required on the part of the inspector to address these potentially serious safety hazards.

6.6. GUARDRAIL

Component		Last	Now	Explanation of Condition
Guardrail (Y/N)				
Guardrail				
Length (m)				
Current Standard (Y/N)				
Termination Type				

6.6.1. Background

Approach guardrails are important safety features and, with a few exceptions, are normally required on all four corners of the bridge. An example where approach guardrail may not be required is at the exiting end of a one-way bridge.

This element must be given a rating based on condition and functionality. Also, the following inventory should be checked or noted:

a) length
b) meets current standard (Y/N)
c) type of termination

For the new curbs and bridgerails used for bridge construction starting in 2001, the approach guardrail standards are as shown on Drawings S-1643, S-1649, S-1651, S-1652 and S-1653.

Photos of a current standard and some previous standards for approach railing are shown below in Figure 6.1 to Figure 6.3.

Figure 6.1 - Current Approach Rail Standard

Figure 6.2 - Previous Standard

Figure 6.3 - Previous Standard

The inspector is required to confirm whether or not the approach road guardrail meets the current standard. When the guardrail does not meet the standard, it is necessary to provide comments in the 'Explanation of Condition' explaining why. Regardless of whether the guardrail meets standards, the rating of the guardrail is based on its condition and ability to function as originally designed. The fact that the guardrail is below the current standard is not a reason for reducing the rating.

Since the current approach guardrail standards have only been used since 2001, a large majority of structures will have approach guardrail that do not meet current standards.

Some sites may not have guardrail on the approach road. In this situation the Guardrail rating is X, Length is 0, meets Current Standard (Y/N) is N and guardrail Termination Type is None. If in the judgment of the inspector a guardrail is required the need for action is stated in the 'Explanation of Condition' and a maintenance recommendation is provided. If the inspector considers the situation hazardous the approach road general rating should be rated 2 and unless another approach road element is rated lower, it will govern. On the other hand, if the situation is not hazardous the recommendation to install a rail would not affect the approach road general rating.

Some possible types of action the inspector could recommend are:

- placing new guardrail or additional posts
- placing additional signing

6.6.2. Inspection and Coding Procedures

- Record the minimum length of the guardrail, to the nearest metre, and note its location if it is shorter than required. If the guardrails are part of the highway rail system, inspect and record the nearest 45 metres from each corner of the bridge.
- Based on the standard drawings note whether the guardrails meet current standards.

- Record the type of termination (i.e. turn down, bulb ends, or others).
- Check guardrail splices and connections with the bridge and guardrail posts, as well as the post spacings.
- Check guardrail installation including transitions, height, and alignment.
- Check the conditions of the guardrail and posts (i.e. all timber for rot and splitting, all steel for rust, and all concrete for chemical attack and/or cracks).

6.6.3. Rating Guidelines

- The rating should only reflect the condition of the guardrail and posts, and its ability to function as originally designed. Guardrail systems that do not meet the current standard should not influence this rating.
- Approach railing that has minor damage but is still functional, rate 5.
- Rail splices with missing bolts or improper laps, rate 4 or less.
- Approach railing that is damaged and requires replacement, rate 3 or less.
- Approach railing that is damaged and is a potential hazard, rate 2 or less.
- Approach railing that is not connected to the bridgerail but is not a potential hazard, rate 5 or less.
- Approach railing that is too high or too low and affects functionality, rate 4 or less.

6.7. DRAINAGE

Component	Last	Now	Explanation of Condition
Drainage			

6.7.1. Background

This item deals with the ability of the approach roads to prevent water from flowing on to the bridge deck and to divert water from the bridge headslopes. It includes the road surface, sideslopes, and ditch drainage of the approaches. Drainage flowing off the bridge onto the approaches will be considered with the approach drainage rating. The actual erosion of the headslope is rated elsewhere (see section 9.3 Slope Protection).

6.7.2. Inspection and Coding Procedure

- Bridges located on grade or at the bottom of sag curves should be checked for proper crown of the road surface, debris build-up along the shoulders and gutters, and clogged catch basins.
- Bridges located on a crest curve or on relatively flat grades (less than 1%), should be checked for potential ponding in low spots or potholes at the bridge ends, as well as those areas noted previously.
- Check bridge headslopes or bank protection works, especially on the upstream side, for erosion due to ditch drainage, etc.
- Any condition that allows water to flow onto the bridge deck should be recorded.

6.7.3. Rating Guidelines

- Approaches that have good drainage away from the bridge, rate 5 or more.
- Any condition that causes drainage to be directed onto the gutter area of the bridge deck, rate 4 or less.
- Any condition that causes drainage to be directed onto the driving lanes of the bridge deck, rate 3 or less.
- Rate 4 or less if water flowing off the bridge is eroding the headslopes and/or sideslopes.
- Rate 4 or less if there is any erosion due to ditch drainage.
- Any condition that causes a hazardous condition or safety concern, rate 2 or less.

6.8. APPROACH ROAD GENERAL RATING

The approach road general rating is governed by:

- horizontal alignment rating
- vertical alignment rating
- safety concerns (e.g. severe approach bump, improper installation of warning signs)
- potential hazards due to drainage problems such as ponding or icing
- a missing approach railing rated X may govern the general rating if it creates a hazardous situation (i.e. rate 2)

7. CHAPTER 7 - SUPERSTRUCTURE

7.1. INTRODUCTION

The superstructure is that portion of the bridge structure, including the bearings, located above the abutment and pier caps. The bridge components of the superstructure are usually made up of one or more of the following materials: timber, concrete, and steel.

7.1.1. Timber

This type of superstructure is generally used for simple span bridges. Details on the properties, mechanics, and defects of timber are given in Chapter 1 of the BIM Reference Manual.

Timber is prone to decay and deterioration under certain environmental conditions and is vulnerable to fire damage. Unlike concrete, the allowable stresses tend to decrease with time. However, timber behaves better than concrete or steel under situations that result in impact or fatigue. The most common types of defects and damage found in timber bridges are:

Decay

This is caused by fungi and is detected by looking for discoloration, soft or spongy surface texture, and fruiting bodies. Fungi growth and propagation require mild temperatures (10 to 32 degrees Celsius), oxygen, and moisture levels above the fibre saturation point. The likely locations to find fungi decay are at bearing areas, connections, around bolts, drift pins, and any break in the factory treatment.

Checks

Wetting and drying of timber causes volume changes which can result in high stresses in the timber. These stresses can cause checks in the timber.

Cracks

Cracks in the timber are generally caused by overloading of the timber member.

Mechanical Wear

This type of deterioration is usually gradual and can be found along the wheel lines on the deck. Deterioration is much more rapid once the wear is deep enough to trap moisture.

Collisions or Overloads

This type of damage is usually recognizable by shattered or splintered timber, deformed or buckled members, or large cracks.

Fire Damage

This type of damage is recognized by charred surfaces.

7.1.2. Concrete

The use of concrete in bridge structures is increasing because of its availability, competitive cost and engineering performance when used with steel. Details on the properties, mechanics, and defects are given in Chapter 2 of the BIM Reference Manual.

The compressive strength of concrete is high, however, the shear and tensile strengths are only about 10% to 12% of the compressive strength. Thus, in order to use concrete in flexural members it is necessary to provide enough reinforcing steel to take the tensile stresses. In ordinary reinforced concrete, the reinforcing steel is in the form of bars, fibres or wire mesh. In prestressed concrete, the reinforcing steel could be either pretensioned (i.e. the steel is stressed before the concrete is placed), or post-tensioned (i.e. the steel is stressed after the concrete has hardened). The most common types of defects and deterioration in concrete are:

Cracks

A crack is defined as a break without complete separation of parts. Cracks can be classified as follows:

a) Structural - these are caused by higher than designed stresses and usually have the same orientation but varying widths. They include flexural, shear and anchorage cracks.
b) Shrinkage - these are caused by rapid drying of the concrete either in the plastic or hardened state.
c) Settlement - these are caused by settlement in the formwork or foundation and are of any orientation and width.
d) Map - these may be caused by a chemical reaction of the aggregates and paste and are closely spaced in all directions.
e) Corrosion - these are caused by the corrosion in steel reinforcement and are generally associated with shallow cover.

Scaling

Scaling is the continuous loss of surface mortar and aggregate. It is usually caused by poor workmanship, inadequate air entrainment, and repeated freezing in the presence of salts. It can also be found under an asphalt wearing surface without a waterproofing membrane. American Association of State Highway and Transportation Officials (AASHTO) classifies scaling as light (less than 6 mm in depth), medium (6 mm to 12 mm in depth), heavy (12 mm to 25 mm in depth), and severe (25 mm or more in depth).

Spalling

Spalling is the complete removal of concrete in pieces up to 150 mm wide and 25 mm deep. It is caused by corrosion of the reinforcement or swelling of poor aggregate.

Popouts

These are small depressions created by expansive or frost-susceptible aggregates that swell as they absorb moisture or expand as they freeze. In many cases, a part of the original aggregate can be found at the bottom of the hole.

Delamination

This is a crack/separation in the concrete generally at the surface of a reinforcing steel layer caused by the corrosion of the steel.

Debonding

This is a separation between two concrete layers (e.g. original deck and concrete overlay) caused by improper preparation of the concrete surface before placing overlay.

Efflorescence

These are white carbonate salt stains which result from the evaporation of a calcium hydroxide solution that flows out of the concrete. Efflorescence may be associated with cracks.

Exudation

This is a solid or gel-like substance that is deposited on the surface. In most cases exudation is associated with surface defects.

Chemical Attack

Sulfates from soil or water react readily with calcium hydroxide in the cement. This results in an increased volume of concrete, thus making it susceptible to disintegration or cracking. Salts and acids are also very aggressive, even in low concentrations.

Fire Damage

This type of damage is recognized by spalling and cracking of the concrete.

7.1.3. Steel

Like concrete, steel is also extensively used in bridge structures in the form of rolled sections, plates and cables. The strength characteristics depend on the grade and chemical composition of the steel. Details on the properties, mechanics, and defects are given in Chapter 3 of the BIM Reference Manual.

Steel has very high strengths in compression, tension, and shear. However, carbon steel is susceptible to corrosion, as well as brittleness due to welding and fatigue. The most common types of defects and damage are:

Corrosion

This type of damage occurs in the presence of oxygen and moisture. It progresses more rapidly in an environment containing aggressive ions such as chlorides which are present in deicing salts. As the level of corrosion increases, pitting in the steel can be seen. This can cause significant reduction in load carrying capacity and increases the risk of fatigue failure. The areas most vulnerable to corrosion are those susceptible to debris accumulation, splash from traffic, and leakage from deck joints and deck drains.

Cracks

Many cracks in steel are too small to be detected by the eye. Cracks may propagate to depths of up to half the plate thickness before the paint or other protective coating is broken. The first sign of the crack is in the form of ripples or rust stains.

Cracks are generally caused by fatigue, overloads, and collisions. Fatigue cracks are the most common type found in highway bridges. They are usually caused by a combination of poor design, improper detail, high stress range under live load, poor workmanship, stress raisers, and inadequate quality control during fabrication and construction. The details most susceptible to fatigue cracking are coverplates, stiffeners, attachments, and splices.

Fire, Collisions or Overloads

These situations may cause cracking, buckling, or distortion of the member. Distortions are also caused by thermal stresses resulting from defective bearings or expansion joints, and fire. Failure or deterioration of adjacent members may also result in misalignment.

7.2. SPAN INFORMATION

Superstructure			
Bridge Component	Last	Now	Explanation of Condition
(Primary Span/Secondary Span)			

The first line on the superstructure section of the inspection form contains span information that is extracted from BIS. The information includes span type (see Table 1.1), number of spans and span lengths. The Ident Number of the superstructure is also printed where applicable. If there is more than one span type in the structure, a separate superstructure section is printed for each span type. The most important span type of the bridge is designated the Primary Span and the other span types are designated Secondary Spans.

7.2.1. Number of Spans

This is a two digit code (i.e., 01 to 99). See Figure 7.1 for span numbering arrangements. Spans are numbered in the direction of increasing chainage, if known, or from west to east or from south to north.

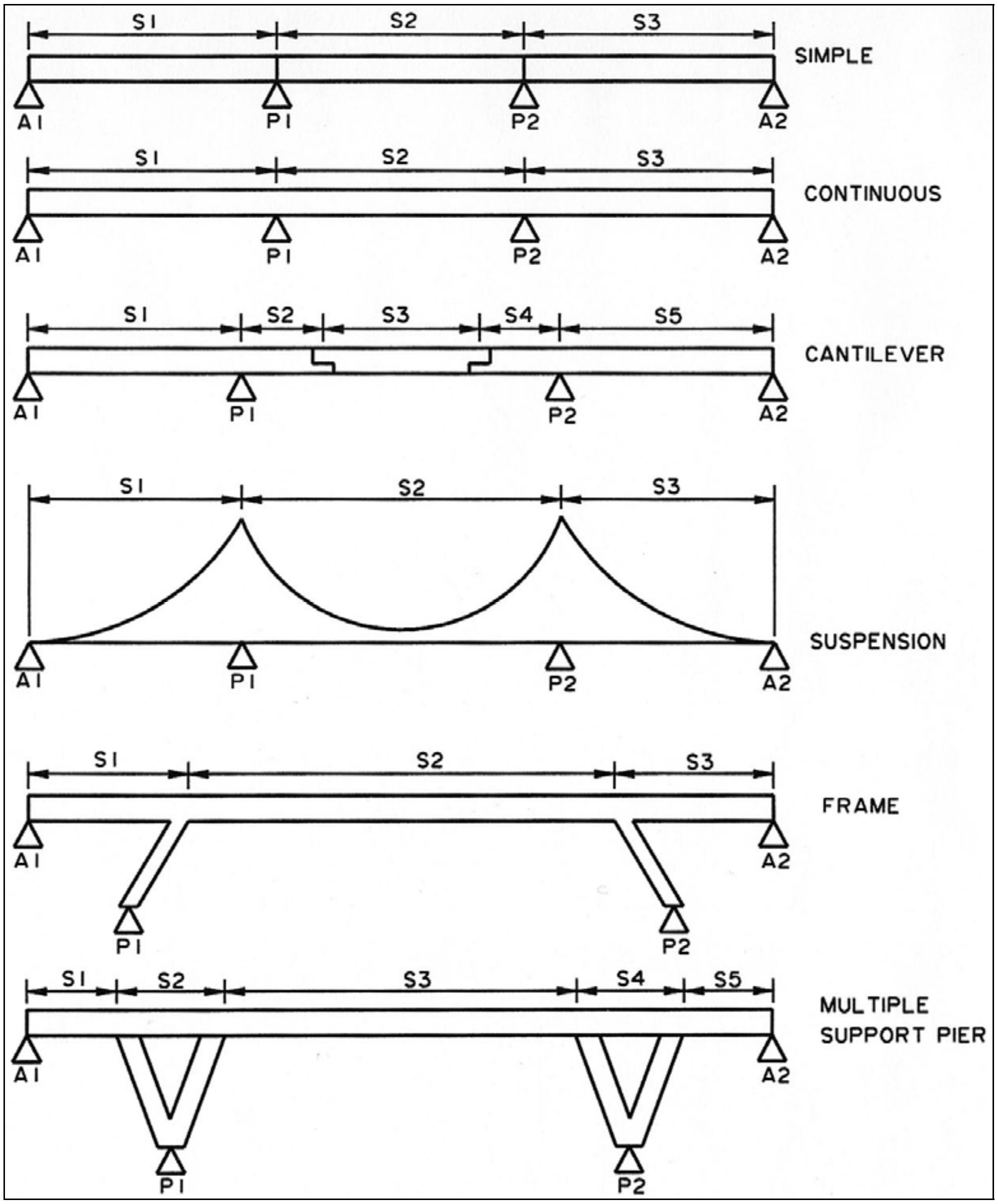


Figure 7.1 - Span Numbering

7.2.2. Span Lengths

The span length is nominal, and noted in metres to the nearest 0.1 metre. The order of the spans is in the direction of increasing chainage (south to north, or west to east). Span lengths are measured from:

a) center of abutment bearing to center of pier
b) center of pier to center of pier
c) center of abutment bearing to center of abutment bearing
d) simple span concrete girders and timber stringers are measured end to end of the girders/stringers

7.2.3. Superstructure Ident

This is a number for steel components that identify the detailed shop drawings that were used in the fabrication of the component. Ident numbers for steel start with an A followed by numeric characters.

7.3. SPECIAL FEATURES

Bridge Component	Last	Now	Explanation of Condition
Special Features			
Special Feature			
(Type :)			
Special Feature			
(Type :)			

7.3.1. Background

Special features on bridges are listed under the superstructure section of the inspection form. These are bridge elements that are unique to a particular bridge and cannot be rated under any other element. It is necessary to record the type of special feature and provide a condition rating for the element. Additional information such as location, dimensions and condition descriptions are to be provided in the 'Explanation of Condition'. Note that these elements may be temporary or permanent features of the bridge.

Some examples of special features that may be on a bridge are:

- dywidag bars for strengthening
- Super-Bolts
- exterior stirrups
- underslung diaphragms
- lateral post-tensioning
- pin and hanger assemblies
- hinges
- clearance detectors
- any instrumentation devices used for monitoring performance

Light standards and Water Survey Canada gauging stations attached along the curbs are treated as utilities and are not rated as special features.

7.3.2. Inspection and Coding Procedures

- Check for common defects and damage as noted in section 7.1.
- Note the type of element and provide a condition rating.
- Use the 'Explanation of Condition' space to note additional information such as location, dimensions, and condition of element.

7.4. WEARING SURFACE

Bridge Component				Last	Now	Explanation of Condition
Wearing Surface/Deck Top Detail Ratings						
	N (%)	1 (%)	2(%)	3(%)		
Last						
Now						
Wearing Surface						
(Material Type :)						
(Thickness (mm) :)						
Lateral Connection Problem (Y/N)						

7.4.1. Background

The wearing surface is bonded or fastened to the bridge deck and is in direct contact with the wheels of vehicles. It protects the bridge deck and provides a smooth riding surface and skid resistance. The wearing surface should extend across the entire bridge deck surface.

Asphalt is a common wearing surface on concrete decks. Concrete overlays are common wearing surfaces on bridge decks that have been rehabilitated. Also, some concrete decks are cast-to-grade with no wearing surface.

The various types of wearing surfaces are listed in section 7.4.2. Loose or frozen gravel is not considered a wearing surface.

The TT, TH & PT inspection forms have a single field to rate either the wearing surface or the deck top. The other bridge forms have separate fields for rating the wearing surface and the deck top.

However, in almost all cases the inspector will only be able to provide a rating in one of these fields (wearing surface or decktop). If there is no wearing surface the wearing surface type should be noted as NONE and X should be recorded in the wearing surface rating field. In the case of forms with a combined field, the top deck rating should be recorded in this field.

There is no simple and accurate method to determine the thickness of the wearing surface on steel and concrete girder bridges. Information is ideally obtained from the design drawings. Typically, precast curb girders are designed for a 300 mm curb height. The exposed curb height will be reduced with the placement of a wearing surface. The placement of a 50 mm thick wearing surface will leave an exposed curb height of 250 mm.

Lacking other information, a simple approximation of the wearing surface thickness can be made by taking the difference between 300 mm and the exposed curb height. Measurements should be taken at midspan and at the ends with the average thickness recorded on the form.

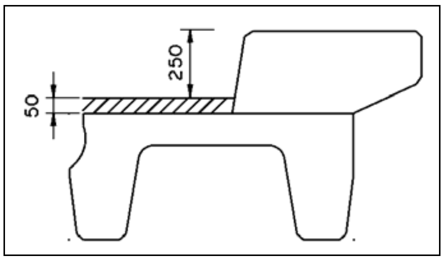


Figure 7.2 - Wearing Surface

If an excessive amount of asphalt (i.e. 100 mm or more) is found on the bridge deck, the wearing surface is not rated down. The wearing surface is rated according to its condition and functionality. A recommendation could be made to reduce the wearing surface thickness. If there are any structural concerns, a request could be made for an evaluation of the bridge's load carrying capacity with the additional asphalt dead load. The problem should be described in the ‘Explanation of Condition’.

The curb rating may be reduced if the curb height is insufficient.

Lateral connection problems should be noted on the form by noting Y/N. This field is only shown on the PSR & PCS forms. Not all concrete girders have lateral connections/grout keys. See section 7.15.2.5 Lateral Connectors and section 7.15.3.4.2 Grout Key Cracks for more details. If there are longitudinal cracks in the wearing surface between the girders that do not have lateral connections/grout keys note N for lateral connection problems and note the cracks in the ‘Explanation of Condition’.

7.4.2. Wearing Surface Types

Wearing surface type, when available, is extracted from BIS and printed on the form. For a specific list of wearing surface types, see BIS documentation. Common types of wearing surfaces for bridges are:

Asphalt

Asphaltic concrete is the most common type of wearing surface found on bridges. It may be placed directly on the concrete deck or there may be a waterproofing membrane between the deck and the asphalt pavement.

Asphalt Plank

This type of wearing surface consists of asphaltic planks that are glued to the deck surface. They are sometimes found on timber subdecks.

Chip Coat

This is a thin wearing surface consisting of asphaltic material and rock chips. It is used to improve skid resistance and to help waterproof the deck surface. It can be placed directly on a concrete deck or on top of an asphalt, concrete or polymer wearing surface.

Concrete to Grade

This is a concrete deck which is cast to final gradeline with extra cover over the reinforcing steel to act as a wearing surface.

Concrete Overlay

This is a concrete wearing surface that is placed on top of a concrete deck. It can be placed at the time of the original bridge construction or can be placed at a later date as part of a deck rehabilitation. There are number of different types of concrete used for overlays (e.g. high density, silica fume, silica fume with fibers, latex modified).

Polymer Overlay

This is a thin overlay consisting of a polymer material (e.g. epoxy) placed on a concrete deck or concrete overlay to waterproof the deck surface. A layer of small rock chips is used to provide skid resistance for the surface.

Steel Grating

This consists of sections of steel grating that function as the deck and the wearing surface on bridge structures (typically trusses) to minimize dead load. The grating is sometimes filled with concrete.

Timber

This is timber planking placed on timber subdeck as a wearing surface.

For chip seal coats, the inspector should make a note in the comments regarding the materials under the chip seal coating, if known (i.e. asphalt, high density concrete, etc.). Chip coats should extend the full width of the bridge deck.

7.4.3. Inspection and Coding Procedures

- Verify or record the type of wearing surface on the BIM form.
- Note the average thickness of wearing surface in millimetres.
- For timber or asphaltic planks wearing surface, record the nominal thickness and width of the planks in millimetres.
- Depending on the type of material used, the inspector should look for the common defects listed in section 7.1.
- Look for the following defects on asphalt wearing surface: cracks (alligator, lane joint, shrinkage, and slippage), distortion (ruts, depressions, corrugations), disintegration (potholes and raveling) and segregation.
- All grout keys where visible should be inspected for longitudinal cracks or other defects.

- Drive over the deck at normal speed or observe traffic to aid in obtaining condition rating.
- If deck needs washing, note in maintenance recommendations.
- Note if wearing surface does not extend all the way to the curbs.

7.4.4. Rating Guidelines

- If a wearing surface is without defects or cracks and is relatively smooth, rate 9.
- If the wearing surface is in relatively good condition but has some form of cracking, rate 7 or less.
- If the speed has to be reduced due to potholes, etc., rate 4 or less.
- If the wearing surface does not extend all the way to the curbs or wheel guards and the condition creates a possible wheel trap, rate 4 or less.
- For Asphalt wearing surfaces
  - Rate 7 or less if there are any longitudinal or transverse cracks.
  - Rate 4 or less if the edges of the cracks have any raveling.
  - Rate 4 or less if the asphalt is rutting.
  - Rate 4 or less if there are any pot holes or debonding.
- For Polymer/Seal Coat wearing surfaces
  - Rate 4 or less with polymer/seal coat debonding or loss greater than 10% of the total area.
- For Concrete Deck and Overlay wearing surfaces
  - Rate 5 if narrow cracks in concrete surface.
  - Rate 4 or less if there are wide cracks in concrete surface.
  - Rate 3 or less if there is severe scaling (aggregate exposed), spalled or debonded areas.
- If there is no wearing surface record X except if this field is also noted as deck top.

7.4.5. Wearing Surface/Deck Top Detail Ratings

Detail Ratings for wearing surface are to be recorded if the Wearing Surface/Deck Top element field is rated 3 or less. In the fields provided record the percent area of the wearing surface that is rated N, 1, 2 and 3. If the wearing surface is rated 4 or above based on worst condition, the detailed rating fields are noted as 0 (zero).

If there is no wearing surface and the deck top is rated 3 or less, Detail Ratings for the deck top should be recorded in the detailed rating fields as described above.

7.5. DECK TOP

Bridge Component	Last	Now	Explanation of Condition
Deck Top			

7.5.1. Background

Deck top refers to the surface on which the wearing surface is bonded. In the absence of a wearing surface, the deck top is in direct contact with the wheels of the vehicles. Inspection of the deck top consists of observations or tests done from the roadway surface. It may be necessary to verify the observations from the top by viewing the deck from the underside.

The primary function of the deck is to carry traffic and transfer live loads from traffic to the main structural members. Deck types include cast-in-place concrete, pre-cast concrete slabs or girders, timber, and steel grating.

If the deck top has a wearing surface that covers the entire deck, the deck top should be rated N.

7.5.2. Inspection and Coding Procedures

- Listen for unusual noise and look for deflections during the passage of traffic.
- On cast-in-place concrete or slab decks, check for cracks, scaling, spalling, pop-outs, chemical deterioration, and dampness.
- On precast or prestress girders, where the top surface is in direct contact with the wheels of vehicles, check for cracks, punch-outs, wear at the edges of girders, scaling, spalling, and un-filled grout pockets.
- On steel grating decks, check for loose connections, improper bearing on supporting members, broken welds or rivets, and corrosion at connections.
- On timber decks, look for missing planks, loose connections, decay, wear, deformation, dampness, and slipperiness. Spot check all timber decks with asphalt overlays for decay.
- The rating of the deck underside may influence the rating of the deck top.
- If deck top is rated 3 or less, record detailed deck top ratings as described in section 7.4.5.

7.5.3. Rating Guidelines

- If the deck top surface is without defects or cracks and is relatively smooth, rate 9.
- If the deck top surface is in relatively good condition but has some form of hairline shrinkage cracking, rate 7 or less.
- If the speed has to be reduced due to potholes, etc., rate 4 or less.

- In addition, for concrete decks
  - Rate 5 if narrow cracks in concrete surface.
  - Rate 4 or less if there are wide cracks in concrete surface.
  - Rate 3 or less if there is severe scaling (aggregate exposed), spalled or debonded areas.

7.6. DECK RIDEABILITY

Bridge Component	Last	Now	Explanation of Condition
Deck Rideability			

7.6.1. Background

Deck rideability is a measure of riding comfort the public experiences when traveling over the bridge deck at the legal speed. This rating is influenced by the condition of the wearing surface/deck top and the deck joints. The condition of these items are rated separately (see section 7.4 Wearing Surface, section 7.5 Deck Top, and section 7.7 Deck Joints). An uncomfortable ride usually indicates the need for maintenance of the deck and/or deck joints.

7.6.2. Inspection and Coding Procedures

- Drive over the deck at legal speed, if conditions permit, to aid in obtaining a proper rating.
- Listen for unusual noise during the passage of traffic.
- Slipperiness of the deck does influence the rating.

7.6.3. Rating Guidelines

- If the deck is smooth and there is no evidence of traffic slowing down for bumps and/or deck roughness, rate 7 or more.
- If the speed has to be reduced due to potholes, etc., rate 4 or less.

7.7. DECK JOINTS

Bridge Component		Last	Now	Explanation of Condition
Deck Joints				
Temperature (deg C)				
(Expansion Type :)				
(Fixed Type :)				
Gap Size (mm)		Gap Location		
Bump (Y/N)				

7.7.1. Background

Deck joints are either fixed or expansion types. Perhaps the most important features of deck joints are water-tightness and/or proper drainage. A leaking joint that allows water or chemicals to reach structural elements such as ends of girders, bearings, abutment and pier seats can cause considerable damage. The second most important feature is firm anchorage throughout the service life of the bridge. Initial signs of failure are indicated by leakage and unusual noise under wheel action.

Open joints like buffer angles and steel sliding plates are not intended to prevent water from leaking onto the substructure. These joints are not rated down because of deterioration to the substructure caused by water from the deck. The substructure ratings should reflect the deterioration caused by the leaking joints.

Asphalt fibreboard alone is not considered a deck joint and is therefore rated X. If the bridge has been paved over and no joint is visible, rate the deck joint N. If the bridge has been paved over but you have information that the bridge does not have a deck joint rate X and provide a comment with a date.

On major bridges, deck joints may be sealed, open joints with plumbing or open joints without plumbing. Sealed joints are designed to be watertight and any leakage of these joints is reflected in both the deck joint rating and the deck drainage rating. Open joints with plumbing are to be treated similarly. Any noticeable problems related to condition and functionality of the associated plumbing are to be reflected in the deck joint and deck drainage ratings. Leakage problems with the third type, open joints without plumbing, are to be reflected in the deck drainage rating only.

Curb cover plates are to be rated under deck joints and not the curb rating.

7.7.2. Deck Joint Type

The deck joint type, when available, is extracted from BIS and printed on the forms. For specific list of deck joint types, see BIS documentation. Common types of deck joints for bridges are:

Finger Plate

This joint consists of two steel plates with interlocking 'fingers' that slide back and forth. The joint usually has a plumbing system underneath to prevent water from leaking onto the substructure.

Sliding Plate

This joint consists of two steel plates which overlap one on top of the other and slide back and forth. The joint may or may not have a plumbing system underneath.

Gland Type

This joint consists of a rubber or neoprene seal held in place by steel extrusions.

Armoured Gland

This is a gland type joint protected by bolted-in-place cover plates.

Compression Seal

This is a joint with a seal consisting of a flexible compressible material that is held in place with buffer angles or concrete. The seal is compressed when placed in the gap so that it remains in compression when the gap expands (e.g. Evazote, Acme and box seals).

Asphaltic Plug Joint

This joint consists of a segment of flexible asphaltic material that spans the gap between the ends of girder spans or between end of a span and backwall (e.g. Koch joint). This type of joint is sometimes referred to as a thermoplastic joint

Water Stop

This joint consists of a flat rubber seal cast into the concrete. This is used for joints with little or no movement (e.g. construction joint).

Buffer Angles

This joint consists of metal angles cast into the concrete on either side of the gap.

Photos of some of these deck joint types can be seen in Figure 7.3 to Figure 7.8.

Figure 7.3 - Finger Plate Joint

Figure 7.4 - Sliding Plate Joint

Figure 7.5 - Gland Joint

Figure 7.6 - Armoured Gland Joint

Figure 7.7 - Asphalt Plug Joint

Figure 7.8 - Buffer Angle Joint

7.7.3. Inspection and Coding Procedures

- Check the joint type printed on the inspection form and correct if required.
- Check all joints for water-tightness, vertical alignment, rust, sound concrete for anchorage, surface deterioration, noise under traffic, and need for maintenance. If buffer angles are used, the joint is not watertight.
- On finger joints, check that the fingers are sitting level, have no cracks, and the trough underneath the joint is in good condition without signs of leakage or debris accumulation.
- On sliding plates, check for cracks in plates, and if plumbing is present check for signs of leakage and debris accumulation.
- On armoured gland joint, check for missing or loose anchor bolts and signs of leakage on the substructure and underside of deck.
- On gland type, check for holes in seal and signs of leakage.
- On compression seal, check for holes in seal and signs of leakage.
- On water stop, check for leakage.
- On buffer angles, check for anchorage and alignment.
- Check all expansion joints for freedom of movement. Record the minimum opening of the gap, and its location. Significant variation in gap opening or vertical alignment at each joint should be recorded. These may indicate horizontal and vertical movement of the bridge.
- Record air temperature at time of gap measurement.
- For bridges that use the PCS form, note traffic crossing bridge and record Y if noticeable bump at any joint with comments on severity.
- Minor surface deterioration or debris accumulation should not warrant significant reduction in the rating.

7.7.4. Rating Guidelines

- Joints that have good anchorage and are handling water as intended, rate 5 or more.
- The rating for deck joints should also include the ability of the joints to function as originally designed. For example, an expansion joint that does not allow for movement should be rated 4 or less. On the other hand, an open joint such as buffer angles that leak and cause deterioration of the substructure should not be rated down.
- Joints that may cause serious malfunctioning of structural components, rate 3 or less.
- Joints that may be hazardous to traffic, rate 2 or less.

7.8. DECK DRAINAGE

Bridge Component	Last	Now	Explanation of Condition
Deck Drainage			
Drains Clogged (Y/N)			

7.8.1. Background

The deck drainage rating takes into account the deck's ability to adequately remove water from the deck surface. In many cases bridge drainage systems do not function properly because of inadequate design and/or maintenance practices. One of the most common causes of deck deterioration is poor drainage. In addition, poor drainage may be hazardous due to hydroplaning or icing and may cause stains, discoloration, or rust due to splashing or leaking. Poor drainage systems not only affect the bridge deck, but also other superstructure components, substructure, bridge headslopes, and sideslopes of the approach roads.

The bridge drainage system includes gutters, inlet boxes, grates, scuppers, pipes, down drains and catch basins.

On decks without any drains, consider the grade of the bridge, crowning of the deck and accumulated debris along the gutter which may prevent the flow of water off the bridge.

Water that flows off the deck and onto the approach is then rated under drainage in the approach road section of the form.

The TT, TH and PT inspection forms do not include drainage as a ratable element.

7.8.2. Inspection and Coding Procedures

- A rating should be provided for all bridge deck types, except timber and open steel grating.
- Check ability of catchbasins to intercept highway drainage if the bridge is located on a grade or in a sag.
- Inspect deck drains for clogging by debris or if they are covered with asphalt.
- Check all drain pipes for clogging and check the stability of the pipes and attachments.
- Check for stains or discoloration on deck, curbs, girder, abutment, and piers. All ponding and areas likely to cause ponding should be identified and recorded.
- Check location of retrofit deck drains on grade separations to ensure that they are not causing icing problems on the road below.
- Check down spouts to determine if the outlets are below the superstructure elements and do not permit any splashing of water onto the superstructure.
- Consider potential hazardous situations caused by ponding water and icing.

7.8.3. Rating Guidelines

- For timber and open steel grate decks, rate X.
- Any condition that impedes the flow of water from the deck, rate 4 or less (i.e. plugged drains, buildup of gravel along curbs, pot holes, etc.).
- Conditions that are hazardous due to deck drainage, rate 2 or less (i.e. icing conditions, ponding in traffic lane).
- Leakage through deck joints that has potential to cause damage to other bridge elements should be reflected in the deck drainage rating.
- The deck drainage should be rated 4 or less if the deck drainage is causing any problems from the deck to its final destination in the stream or highway drainage below. (i.e. erosion of headslope, problems caused by deck drainage draining on the superstructure or substructure elements and causing deterioration, broken drains, etc.). This also applies to drainage through snow slots that is causing damage to superstructure or substructure elements.

7.9. CURBS / MEDIAN

Bridge Component		Last	Now	Explanation of Condition
Curbs/Median				
(Type :)				
Scaling (Percent Area)				

7.9.1. Background

These are raised surfaces located at the edges of the roadway and are used to guide or redirect traffic. In some cases, curbs help to minimize damage to other bridge components. Curbs constructed from timber or steel are called wheel guards (see section 7.10 Wheel Guards). Medians are used to divide the bridge according to the direction of travel. A concrete curb consists of the vertical or sloped face along the edge of the roadway, the fascia, and the raised horizontal surface. Concrete barriers/parapets are to be considered a curb element and rated in accordance with this section.

7.9.2. Curb/Median Types

The type of curb/median, when available, is extracted from BIS and printed on the form. The inventory information is to be verified by the inspector in the field. For a list of specific curb/median types see BIS documentation. Curb/median types will be either None, Standard or Concrete Parapet (e.g. New Jersey, F-Shape, etc.).

7.9.3. Inspection and Coding Procedures

- Look for snowplow and other damage, alignment, and loss of height resulting from paving or debris accumulation.
- Check concrete curbs for spalls, scaling, cracks, exposed voids, accident damage, or other deterioration.
- Estimate the area, in percentage, of scaling for the total area of curbs.

- Check condition of material used (if any), to seal curbs.
- Check for unsightly water stains on the fascia.
- Check joints for signs of differential movement, both vertically and horizontally.
- Check expansion joints for freedom of movement and cracking due to insufficient travel.
- Record any deformation at the pier locations.

7.9.4. Rating Guidelines

- Curbs/Medians that require no maintenance, rate 5 or more.
- Curbs with exposed voids that allow moisture to accumulate inside the curb, rate 4 or less.
- Curbs with severe scaling (exposed aggregate and greater than 25 mm deep), rate 4 or less.
- Curbs with broken concrete around anchor assemblies for bridgerail posts, rate 3 or less.

7.10. WHEEL GUARDS

Bridge Component	Last	Now	Explanation of Condition
Wheel Guards			
(Type :)			
(Thickness (mm) :)			
(Width (mm) :)			

7.10.1. Background

Wheel guards are curbs made out of timber or steel (see section 7.9 Curbs / Median for more information). They are commonly found on timber bridges, through trusses, and pony trusses.

7.10.2. Inspection and Coding Procedures

- Rate the overall condition of the wheel guards including the connections and blockings.
- Check for poor anchorage, misalignment, collision damage, and missing sections.
- Check timber wheel guard for decay, splits, and checks.
- Check steel wheel guard for corrosion.
- Note any significant loss of height due to roadway paving or debris accumulation.
- Record the type and size of wheel guard top plate.

7.10.3. Rating Guidelines

- Wheel guards with minor splinters or cracks but are still functional, rate 5.
- Wheel guards with anchor bolts that are damaged, missing or not functioning, missing blocking, broken sections or not functioning as designed, rate 4 or less.

7.11. BRIDGERAILS & POSTS

Bridge Component	Last	Now	Explanation of Condition
Bridgerail			
(Type :)			
Bridgerail Posts			
(Type :)			
Bridgerail/Post Coating			
(Type :)			

7.11.1. Background

Bridgerails and posts are considered safety features, and do not contribute to the strength of the bridge. They include pedestrian rails generally found on sidewalks.

7.11.2. Bridgerail, Post and Coating Types

The type of bridgerail, post and coatings, when available, is extracted from BIS and printed on the form. The inventory information is to be verified by the inspector in the field. For a list of specific rail, post and coating types see BIS documentation. Common types of rails, posts and coatings are described below:

Rail Descriptions

Guardrail

The bridgerail consists of one or more layers of steel w-beam or thrie beam type rail.

Steel Panel

The bridgerail consists of steel panels with vertical, horizontal or lattice members.

Steel Tube

The bridgerail consists of one or more horizontal tubular steel members.

Timber

The bridgerail consists of horizontal timber members.

Aluminum

The bridgerail consists of horizontal tubular aluminum members. Aluminum material is no longer used for bridgerailing.

Post Descriptions

Concrete

The post consists of a reinforced concrete vertical member.

Steel

The post consists of a steel vertical member.

Timber

The post consists of a timber vertical member.

Coating Descriptions

Galvanizing

Bridgerail material has a hot-dipped galvanized coating.

Paint

Bridgerail material has some type of painted coating.

None

Bridgerail material has no coating. This would be common for concrete and timber bridgerails. Concrete sealer and timber treatment are not considered coatings.

7.11.3. Inspection and Coding Procedures

Look for collision damage, horizontal and vertical misalignment, loose connections or missing bolts or nuts at the joints, posts and curbs and determine if these elements constitute a hazard to traffic.

- Check all concrete components for cracks, spalls, and other deterioration.
- Check all timber components for decay, cracks, and splitting.
- Check all steel components for cracks and corrosion.
- Check the anchor bolts to ensure there is sufficient thread to fully engage the nut.
- The rating for bridgerail and posts considers the physical condition only and not the condition of the coating which is rated separately.
- If flexbeam is used on the bridge, record the number of layers of flexbeam in the 'Explanation of Condition'.
- Record the type of coating for the rail and posts and rate the condition of the coating.
- If the coatings on the rail and posts are different, the inspector is to record and rate the rail coating. The coating type for the post and any condition problems should be noted in 'Explanation of Condition'.
- Check if splices in flexbeam are done properly (i.e. lap should be in the direction of traffic).

7.11.4. Rating Guidelines

- The ratings should be based on the condition and not the standard of the rail, rail coating, and posts. For example, although timber rails are substandard, they can receive a 9 rating if they are in excellent condition.
- A rail that has minor collision damage but has good connections and is functional, rate 5.
- For timber railings, rate 4 or less for any sign of rot in the rail or posts.
- For all connections with missing bolts, improper laps, loose connections or nuts that are not fully engaged, rate 4 or less.
- For bridgerail posts with broken anchor assemblies, missing anchor bolts/nuts, rate 3 or less.
- A rail with missing sections, rate 2 or less.

7.12. SIDEWALK

Bridge Component	Last	Now	Explanation of Condition
Sidewalk			

7.12.1. Background

Most sidewalks are designed to accommodate pedestrian traffic without being part of the load carrying system. However, if they contribute to the structural strength of the bridge, the inspection procedures are similar to that of the Deck Top and/or Girders. Generally, a concrete sidewalk would eliminate the need for a curb. In this case, the sidewalk consists of the vertical or sloped face along the edge of the roadway, the fascia, and the raised horizontal surface.

7.12.2. Inspection and Coding Procedures

- Check the surface for smoothness (tripping hazards), adequate traction, and debris.
- Check concrete sidewalk for spalls, scaling, cracks, and other deterioration.
- Check steel sidewalk for corrosion, especially at the connections.
- Check timber sidewalk for decay, loose or missing planks, cracks, and any other conditions hazardous to pedestrians.
- Check all structural connections and members that transfer loads to the bridge.
- The rating should reflect the effects of the current condition of the sidewalk with respect to its ability to accommodate pedestrian traffic. Spalls, cracks, etc., are generally less serious on a sidewalk than on a bridge deck.

7.12.3. Rating Guidelines

- For any condition that may be hazardous to pedestrians, rate 2 or less.

7.13. STRINGERS

Bridge Component			Last	Now	Explanation of Condition
(No. of Stringers:)					
Stringer Detail Ratings					
	N (count)	1 (count)	2 (count)	3 (count)	
Last					
Now					
Stringers					
(Type :)					
(Width (mm) :)					
(Depth (mm) :)					
(Spacing (mm) :)					

7.13.1. Background

Stringers are relatively short longitudinal beams that support the deck and transfer loads either directly to the substructure or to secondary structural members such as floor beams. Stringers are generally timber or steel beams. For the purpose of this manual all concrete beams will be considered as girders (see section 7.14 Concrete Girders).

This section applies to Treated Timber (TT), Through Truss (TH) and Pony Truss (PT) inspection forms.

Sometimes additional stringers are added after the bridge has been constructed. These stringers may have either been added as 'sister' stringers to replace cracked or broken stringers that remain in place (see Figure 7.9) or may have been added as extra stringers to strengthen the floor system. If the added stringer is beside a cracked or broken stringer (i.e. 'sister' stringer), then the cracked or broken stringer and the 'sister' stringer count as one stringer. However, if the extra stringers are for strengthening they should be included in the count of total number of stringers in the bridge.

Figure 7.9 - 'Sister' Stringer

If the size of these stringers is different than the original stringer, the size of the new stringer should be recorded in 'Explanation of Condition'. If these extra stringers exist across the entire width of the bridge, the distance between the new and original stringers should be recorded in the 'Spacing' field. However, if these extra stringers only exist in the wheel paths the spacing of the original stringers should be recorded in the 'Spacing' field and the existence of the wheel path stringers and the resultant spacing recorded in 'Explanation of Condition'.

7.13.2. Stringer/Girder Numbering

Girders or stringers are numbered west to east or south to north (see Figure 7.10).

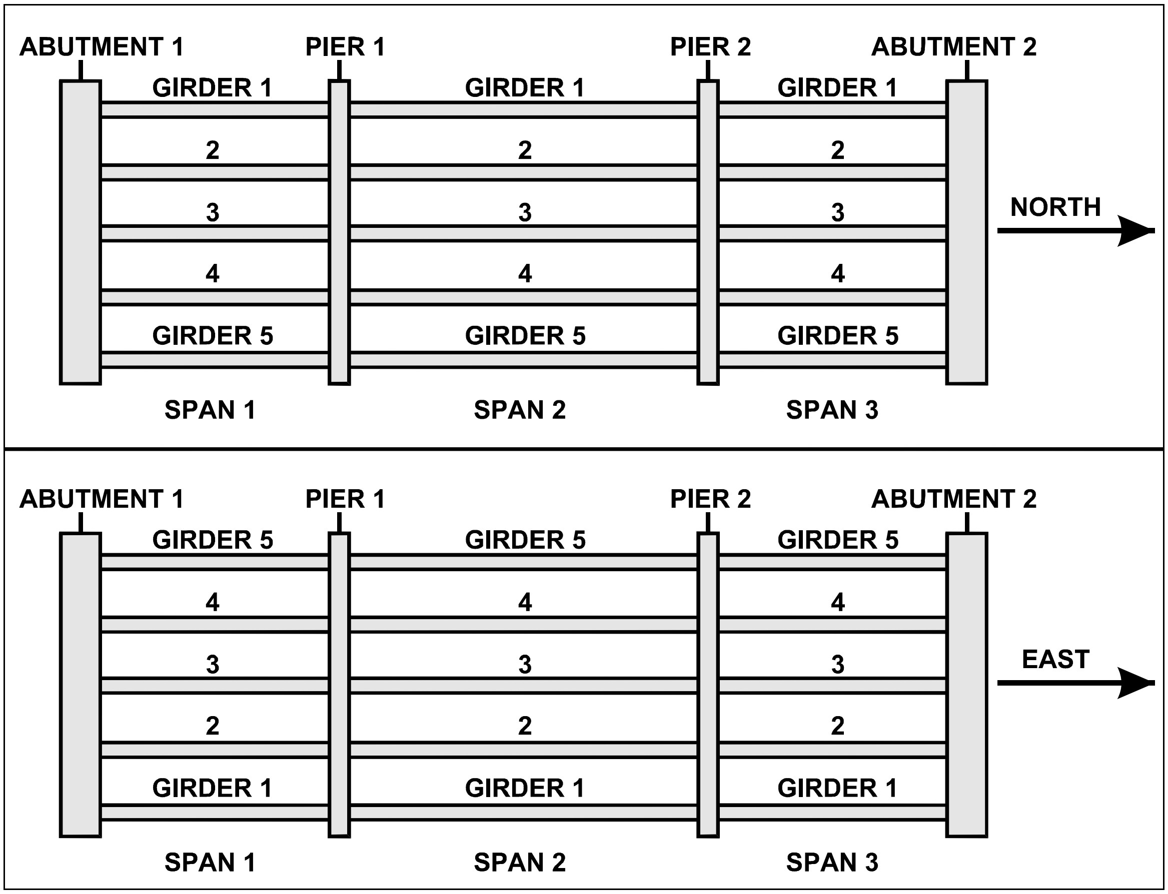


Figure 7.10 - Stringer/Girder Numbering

7.13.3. Inspection and Coding Procedures

- Record the total number of stringers in bridge.
- Cracked or broken timber stringers that have been repaired with 1 or 2 'sister' stringers, shall count as one stringer.
- Stringers that have been added to strengthen floor systems are counted in the total number of stringers.
- Record the type, size, and spacing of all stringers.

- For bridges with more than one span length and stringer size, record the size of shorter spans in 'Explanation of Condition'.
- For extra stringers only in wheel paths, record stringer size and spacing in 'Explanation of Condition'.
- Examine all stringers for proper bearings and connections, sags, horizontal curvature, cracks, and damage due to overloads, high-loads, drift, or fire.
- Check timber stringers for splitting, crushing, and decay.
- Check steel stringers for corrosion, especially at areas susceptible to dirt and/or moisture accumulation.
- Location of missing or broken stringers must be noted.
- Record stress raisers such as notches, etc.

7.13.4. Rating Guidelines

- Timber stringers with notches at the ends, rate 7 or less.
- Timber stringers that have an additional 'sister' stringer(s) installed beside a stringer with severe defects, rate 5 or more. The defect and the additional stringer(s) should be noted in the 'Explanation of Condition'.
- Stringers that are significantly bowing horizontally or vertically from the original lines, rate 4 or less.
- Cracked stringers should be rated 3 or less.
- Timber stringers with a bearing length less than 75 mm, rate 4 or less.

7.13.5. Stringer Detailed Ratings

For timber stringers, quantified information is gathered if the stringers are rated 3 or less. In the fields provided record the number of stringers rated N, 1, 2 and 3. If the stringers are rated 4 or above based on worst condition, the detailed rating fields should be recorded 0 (zero). If the stringers are steel the detailed ratings field are shaded and no entry is required.

7.14. CONCRETE GIRDERS

Bridge Component			Last	Now	Explanation of Condition
Girder Detail Ratings					
	N (count)	1 (count)	2 (count)	3 (count)	
Last					
Now					
Girders					
Last Complete Inspection Date					
Cracking (Y/N)					
Spalling (percent Area)					
Lift or Connector Pocket Grouted (Y/N)					
(Number of Girders :)					

7.14.1. Background

Concrete girders are divided into the following four categories:

a) Precast - conventionally reinforced girders

b) Standard Prestressed - relatively short girders with pre-tensioned reinforcement

c) Regular Prestressed - long girders with either pre-tensioned or post-tensioned reinforcement

d) Cast-in-Place - the girders are composite with the deck and are formed and cast in the field

Girders are primary structural components and their condition, especially in a single or two girder system, is very important to the integrity of the bridge. One of the visible signs of girder deterioration is cracks. Hairline cracks found in precast girders are not indicative of girder distress, but generally speaking, all cracks should be considered serious unless an engineering analysis determines that they can be tolerated. Vertical cracks in the tension zone generally indicate flexure. Diagonal cracks in the vicinity of supports may be due to a combination of shear and tension. Longitudinal cracks in girder legs may be caused by corrosion of the reinforcing steel. Longitudinal cracks on flanges near the web are likely caused by flexure and insufficient stirrups.

The inventory Y/N question for cracking applies to all types of cracking except hairline shrinkage cracks and hairline or narrow flexure cracks. Answer Y (yes) if there are any signs of shear, longitudinal or medium or wide flexure cracking. As with all inventory Y/N questions, Y (yes) answers require a description in the 'Explanation of Condition'.

7.14.2. Inspection and Coding Procedures

- Examine all girders for cracks. The size and location of cracks should be noted for future comparisons. Significant structural cracks should be marked at the end and dated. All cracks that tend to open and close under traffic should be reported immediately to the Bridge Manager.
- Note excessive vibrations and deflections under traffic. Also, observe if girders deflect independently on a system that is tied laterally.
- Look for misalignment, offset at hinges, and spalls, especially in the vicinity of bearings.
- On post-tensioned girders, check the end anchorages if they are accessible.
- Check for discoloration which may result from corrosion of reinforcement or moisture from deck drainage or joints.
- Check for high load damage. All exposed steel should be noted and reported. Any nicked or severed strands on prestressed girders should be reported immediately.
- For standard precast/prestressed, record whether lift or connector pockets are grouted.
- Record or verify total number of girders in bridge.
- Hairline cracks on precast girders should not be reason for a lower rating.
- The inspector should note the condition that governs the concrete girder rating and also give some indication of the extent of the problem by noting location, width and extent of cracking (e.g. wide longitudinal cracks in both legs of the girder within the anchorage zone – 6 girders).

7.14.3. Rating Guidelines

The condition rating of concrete girders is complex. The significance and impact of visible defects such as cracks and spalls depends not only on the extent of the defect but also its location on the girder and the type of girder. A detailed Rating Guide is shown in section 7.15 and the inspector should refer to this section when assigning ratings to concrete girders.

7.14.4. Last Complete Inspection Date

This is a field on the inspection form to record the date of the last complete inspection of the girders. This date is entered by the inspector at the time of either a Level 2 inspection or a Level 1 inspection when all of the girders are accessible, such as off the ice in winter. If all the girders are not accessible for inspection, the previously entered date, if available, is carried over.

7.14.5. Detailed Rating of Standard Precast/Prestressed Girders

For standard precast/prestressed girders, quantified inspection data is gathered if the girders are rated 3 or less. In the fields provided record the number of girders rated N, 1, 2 and 3. If the girders are rated 4 or above based on worst condition, the detailed rating fields should be recorded 0 (zero). If girders are not standard precast/prestressed concrete also record 0 (zero) in detailed rating fields.

7.15. CONCRETE GIRDER RATING GUIDE

7.15.1. Introduction

This guide is to be used by the inspector when assigning appropriate ratings to reflect the condition and functionality of precast and prestressed concrete girders. However, with proper experience, knowledge, judgment and background, the inspector may assign ratings other than that shown in the guide. Any deviation from the guide must be clearly described in the comments section of the inspection form and is generally reserved for Class A Inspectors.

The concrete girder rating guide is organized somewhat differently than the rating guidelines for other bridge components. Commentary, explanations and background information is provided along with the rating guidelines. The guide is organized into three main sections:

- Section 7.15.2 contains information that applies to all concrete girders.
- Section 7.15.3 contains information on rating standard reinforced concrete channel girders. The first part of this section describes the evaluation of various defects typically found in these standard channel type girders and the assignment of appropriate ratings. At the end of the section is a table summarizing the rating guidelines for these types of girders.
- Section 7.15.4 of the guide contains information on rating prestressed concrete girders. There again, the first part of the section provides details on the assignment of ratings to defects typically found in prestressed girders followed by tables summarizing the rating guidelines and listing exceptions for different types of prestressed girders.

7.15.2. Rating Concrete Girders - General

7.15.2.1. Definition of Crack Width

Crack width definitions are as follows:

- Hairline less than 0.1 mm
- Narrow 0.1 mm to less than 0.3 mm
- Medium 0.3 mm to less than 1.0 mm
- Wide equal to or greater than 1.0 mm

Note that little emphasis is placed on the presence of hairline cracks. The only reference made to the rating of hairline cracks is for prestressed concrete girders.

7.15.2.2. Definition of Staining

Inspectors are to distinguish between corrosion staining and water staining. Corrosion staining and water staining represent two different stages of deterioration and this is to be reflected in the rating. Any references to staining in the rating guide apply to visible corrosion stains originating from reinforcing steel or prestressing strands (generally red or rust coloured staining). The one point rating reductions are not to be applied due to the presence of water staining (generally white or grey coloured staining).

- staining refers to corrosion stains suspected to be originating from reinforcing steel or prestressing strands
- one rating point reductions are not to be applied for the presence of water staining

7.15.2.3. Rating for Corrosion of Reinforcing Steel

The following information is provided for the rating of corrosion of reinforcing steel. This defect can only be evaluated when the reinforcing steel is exposed and visible due to a spall in the concrete.

- Light rate 5 - surface rust with no significant section loss
- Moderate rate 4 - moderate loss of section on main bars or stirrups (up to 10%)
- Heavy rate 3 - up to 20% section loss (i.e. loss of ribbing or profile)
- Severe rate 2 - severe loss of section on main bars or stirrups (greater than 20%)

The above corrosion ratings apply to the main longitudinal reinforcing bars as well as any exposed shear stirrup reinforcing bars.

7.15.2.4. Lift Hook and Connector Pockets

Note the condition of the lift hook and connector pockets in the standard precast and prestressed concrete girders. Any deteriorated pockets or asphalt filled pockets are to be noted in the comments and recommended for maintenance (i.e. fill pockets with non-shrink concrete grout).

- evaluate condition of lift hook and connector pockets
- recommend maintenance for any deteriorated or asphalt filled pockets
- type HC girders with deteriorated pockets or asphalt filled pockets are to be rated 4 or less

7.15.2.5. Lateral Connectors

A number of girder types are designed to share live load by laterally connecting the girder units. With the failure or breakdown of the lateral connection element, load sharing among adjacent girders is lost and there is a potential for overstressing the girder.

For standard precast concrete girders, lateral connection elements typically consist of either bolted connections at deck level (Type HC girders), bolted girder legs (Type PA girders) or grout keys (Type PE and PES girders). Inspectors are reminded that some girder types have no lateral connection and are intended to carry the entire wheel load without load sharing to adjacent girders (Type PG girders).

Figure 7.11 - Lateral Connection Failure

The rating of grout key cracks is further discussed in section 7.15.3.4 Other Defects. Some major girder types have lateral connection elements such as grout keys combined with bolted connections through the girder legs, lateral stressing strands through the girder legs or underslung diaphragms and post-tensioning strands at the deck level. Inspectors should refer to the standard drawings for additional information on lateral connectors for specific girder types.

Signs of possible lateral connection failure are:

- wide cracks in ACP wearing surface over lateral connectors (for asphalt wearing surfaces wide cracks are defined as 2-3 mm)
- visible deflection of a single girder unit under live load
- sheared, broken or severely corroded connector bolts
- severely corroded connector plates

7.15.2.6. Standard Precast/Prestressed Girders – Reduced Bearing Length

Standard precast/prestressed girders may bear directly on the substructure or may have a thin neoprene bearing strip between the girder and substructure. Misalignment problems between the girder and the substructure can occur which may result in a reduced bearing length at the girder end. Standard precast/prestressed girders with a bearing length less than 75 mm are to be rated 4 or less.

7.15.2.7. One Rating Point Increase for Curb Girder

To reflect the lower live load carrying function of curb girders, the rating guides for standard reinforced concrete channel girders and prestressed concrete girders include a provision for a one rating point increase if the defect is limited to the curb girder only.

- rating may be increased by one rating point if crack or defect is limited to the curb girder
- this rating increase is applicable to all concrete girder types

7.15.3. Rating Standard Reinforced Concrete Channel Girders

The following commentary describes the evaluation and assignment of appropriate ratings for various defects typically found in standard reinforced concrete channel girders. See Table 7.2 for summary of rating guidelines for these girders.

7.15.3.1. Anchorage Zone

The length of the channel girder is separated into two zones. The two defined zones are the ‘anchorage zone’ and ‘outside the anchorage zone’. The anchorage zone is a defined length at each end of the girder and is where the longitudinal reinforcing steel is ’developed’ or anchored by bonding to the concrete around it. The remaining length of the girder is defined as ‘outside the anchorage zone’. Figure 7.12 shows the two zones.

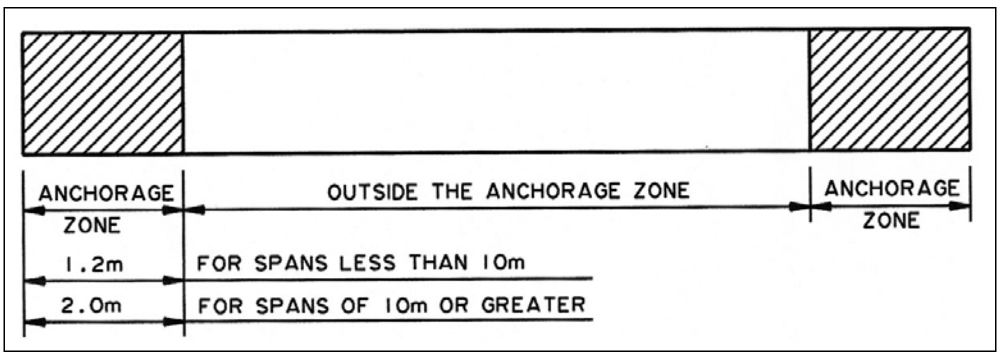


Figure 7.12 - Standard Channel Girder – Anchorage Zone

7.15.3.2. Spalling and Longitudinal Cracks

To properly evaluate and rate spalling and longitudinal cracks on standard reinforced concrete channel girders the inspector must determine:

- where the spall or crack is located on the girder
- the crack width
- bond conditions between the longitudinal reinforcing and surrounding concrete

The longitudinal reinforcing steel in the girder is only effective if the bar is embedded or surrounded by sound concrete. A review of other research literature provided the following information on the effect of spalling and cracking on bond strength.

- 50% bond loss when 25% of the perimeter of the bar is exposed due to a spall
- 10% bond loss with a longitudinal crack 2.5 mm wide

In addition to the bond strength developed by concrete embedment, further bond strength is provided by the shear stirrup reinforcing steel that loops under the bundled main longitudinal reinforcing bars.

7.15.3.2.1. Rating Point Increases

There are specific types of standard girders which have longitudinal reinforcing details that include hooked or cranked bars. Figure 7.13 shows a girder with a straight reinforcing bar, hooked reinforcing bar and a cranked reinforcing bar respectively.

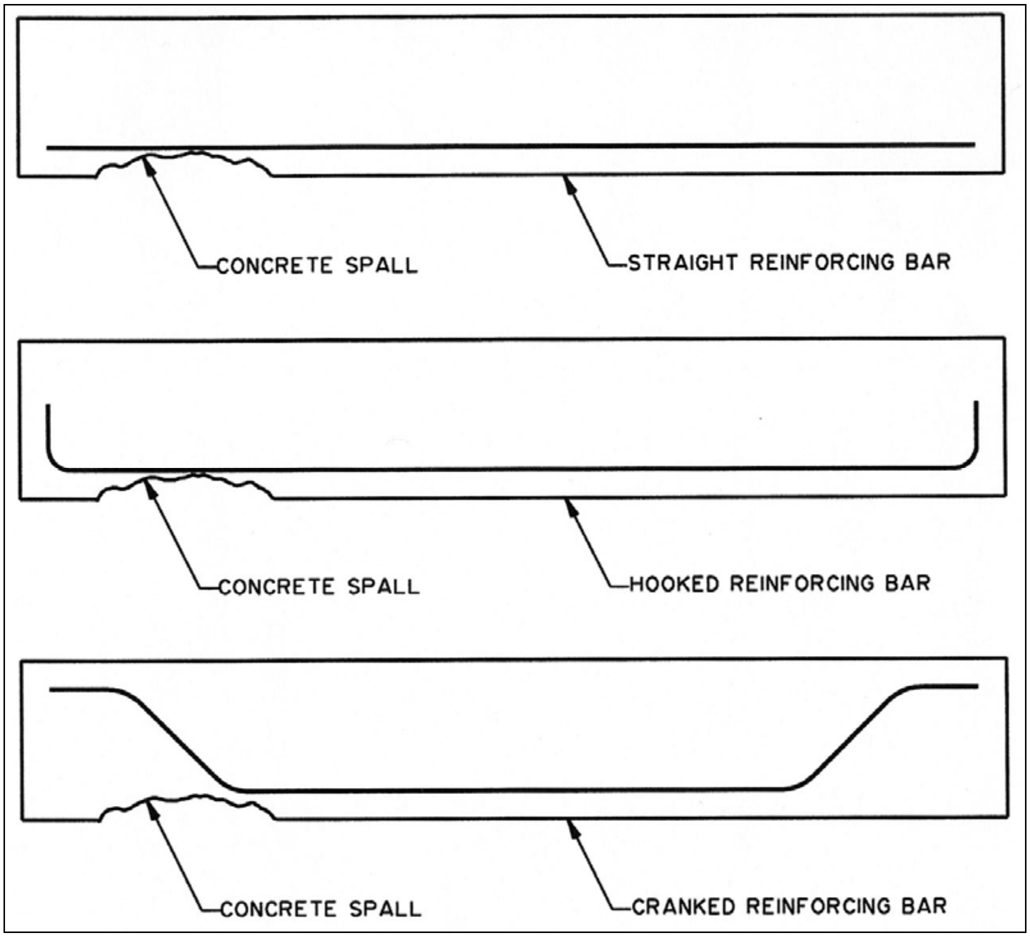


Figure 7.13 - Standard Channel Girder–Straight, Hook and Cranked Longitudinal Bars

It is evident from the review of the above sketches that a spall or crack within the anchorage zone of a girder with a hooked or cranked reinforcing bar is not as severe as having a spall or crack within the anchorage zone of a girder with a straight reinforcing bar. As a result, the rating guide includes a provision to increase the rating for spalling or longitudinal cracks by one rating point if the specific girder type has hooked or cranked longitudinal reinforcing steel.

The specific girder types that have hooked and cranked bars and are eligible for this one rating point increase are the Type PG and Type PA girders. The BIM inspection form will display the girder type on the top of the superstructure section. However, the following table provides some girder properties that may be used to help identify Type PG and PA girders in the field.

Girder Type	Depth	Width	Lateral Connection	Available Lengths
Type PG	406 mm	914 mm	None	6.1 m 8.5 m
Type PA	406 mm	914 mm	None	6.1 m

Table 7.1 - PG and PA Girder Properties

Under live load, the two legs of the channel girder combine to distribute and carry the live load. In the event that one of the legs has a defect, its load carrying capacity is affected and the load is shed or redistributed to the other leg of the girder. Provided the other leg is free of spalling or longitudinal cracks, the rating guide includes a provision to increase the rating for spalling or longitudinal cracks by one rating point. Note that the entire length of the other leg must be free of any spalling or longitudinal cracks for this one rating point increase to apply.

The above describes the two situations where the rating for spalling and longitudinal cracks may be increased by one rating point. It is very important to note that the girder is not eligible for both the one rating point increase for spalling or longitudinal cracks limited to one leg on the girder and the one rating point increase for girders with hooked or cranked bars. Only one of these increases may be applied as the increases are not cumulative. However, if the defect is limited to the curb girder only, the rating is eligible for an additional one rating point increase as discussed in section 7.15.2.7 One Rating Point Increase for Curb girder.

7.15.3.2.2. Rating of Spalling and Longitudinal Cracks in Anchorage Zone

Inspection and Coding Procedures

- Identify the length of the girder that is within the anchorage zone.
- Anchorage zone is 1.2 m from the end of the girder for all spans less than 10 m.
- Anchorage zone is 2.0 m from the end of the girder for all spans 10 m or greater.
- If accessible, confirm whether concrete around medium and wide longitudinal cracks is sound.
- One rating point increase is allowed for Type PG and Type PA girders which have hooked or cranked main longitudinal reinforcing bars.
- One rating point increase is allowed if spalling or longitudinal cracks are limited to a single leg on the girder.
- The rating is eligible for only one of the above rating increases (rating point increases are not cumulative).
- The rating is eligible for an additional one rating point increase if defect is limited to curb girder only.

Rating Guidelines

- Medium crack within anchorage zone where inspector can confirm sound concrete, rate 5.
- Medium crack within anchorage zone with unsound concrete or where soundness cannot be confirmed, rate 4.
- Wide crack within anchorage zone where inspector can confirm sound concrete, rate 4.
- Wide crack within anchorage zone with unsound concrete or where soundness cannot be confirmed, rate 3.
- Spall within the anchorage zone with the top half of the main longitudinal reinforcing steel embedded in sound concrete, rate 3.
- Spall within anchorage zone with unsound concrete extending above the top half of the main longitudinal reinforcing steel, rate 2.

Example:

- Type PG girder with wide crack in the anchorage zone in one leg only with sound concrete around crack.
- Rating guide states wide crack in anchorage zone with sound concrete, rate 4.
- Girder type is eligible for one rating point increase due to hooked or cranked bars.
- Girder is also eligible for one rating point increase due to the defect limited to one leg.
- Since these increases are not cumulative, rating is now 5 for an interior girder.
- If this was a curb unit, the rating would be eligible for an addition one rating point increase and the rating would be 6.

7.15.3.2.3. Rating of Spalling and Longitudinal Cracks Outside the Anchorage Zone

Inspection and Coding Procedures

- Identify the area along the length of the girder that is outside the anchorage zone.
- One rating point increase is allowed if spalling or longitudinal cracks are limited to a single leg on the girder.
- The rating is eligible for an additional one rating point increase if defect is limited to curb girder only.

Rating Guidelines

- Wide crack or spall outside anchorage zone, rate 5.

7.15.3.3. Shear Cracks

The shear capacity of the girder is highly dependent upon the anchorage of the longitudinal reinforcing steel. The guide includes a one rating point reduction to the shear rating if the girder has spalling or wide cracks within the anchorage zone.

Note that the one rating point increase if the defect is limited to a single leg on the girder, as discussed in section 7.15.3.2, is not applicable to shear cracks..

Inspection and Coding Procedures:

- Reduce shear crack rating by one rating point if the girder has spalling or wide cracks within the anchorage zone.

Rating Guidelines

- Narrow shear crack, rate 5.
- Medium shear crack, rate 3.
- Wide shear crack, rate 2.

7.15.3.4. Other Defects

7.15.3.4.1. Punchouts

Punchouts are small conical holes found on the deck underside of a concrete girder.

Inspection and Coding Procedures

- Reduce the punchout rating by one rating point if the punchout is located near a lift hook pocket, connector plate or midspan of the girder.

Rating Guidelines

- Small punchouts, identified as 150 mm or less in diameter measured on the underside of the deck, rate 4.
- All other punchouts, rate 3 or less.

7.15.3.4.2. Grout Key Cracks

A grout key is a longitudinal keyway along the side of the girder that, when paired with an adjacent girder and filled with concrete or a grout material, form a type of lateral girder connection which allows load sharing between girders. For standard precast concrete girders, the only girder units with a grout key are the Type PE and PES girders. Inspectors are reminded that a bolted connection in a Type HC girder is not considered a grout key.

Inspection and Coding Procedures

- Check for cracks in grout key concrete.
- Rating should reflect condition of the grout key and its ability to transmit load to adjacent girder.
- Cracks in asphalt overlay or cracks originating from a bolted connection are not indicators of a grout key failure.

Rating Guidelines

- Narrow concrete grout key crack, rate 4.
- Medium or wide concrete grout key crack, rate 3.

7.15.3.4.3. Flexural Cracks

Flexural cracks are usually vertical cracks that develop in the tension zone. For simple span girders these cracks are found in the bottom half of the girder legs around midspan. Reinforced concrete girders, that are not prestressed, would normally have narrow flexural cracks.

Rating Guidelines

- Medium flexural cracks, rate 4.
- Wide flexural cracks, rate 2.

7.15.3.5. Summary of Rating Guide for Standard Reinforced Concrete Channel Girders

Rating	Spalling or Longitudinal Cracks on Legs	Shear cracks (not greater than 60º from horiz.)	Other Defects
No effect			▪ Narrow flexural cracks.
6			▪ End diaphragm spall. ▪ Narrow map cracks.
5	▪ Medium crack within anchorage zone with sound concrete (must be accessible and confirmed by inspector). ▪ Wide crack or spall outside anchorage zone.	▪ Narrow (reduce by one if wide longitudinal crack or spall within anchorage zone).	▪ Top slab transverse crack.
4	▪ Medium crack within anchorage zone with unsound concrete or concrete soundness not confirmed by inspector. ▪ Wide crack within anchorage zone with sound concrete (must be accessible and confirmed by inspector). ▪ Moderate loss of section on main bars or stirrup bends (up to 10%).		▪ Medium or wide map cracking or any map cracking with staining. ▪ Medium flexural cracks. ▪ Small punchouts, 150 mm or less in diameter. ▪ Narrow concrete grout key cracks. ▪ Bearing length less than 75 mm (rate 4 or less).
3	▪ Wide crack within anchorage zone with unsound concrete or concrete soundness not confirmed by inspector. ▪ Spall within anchorage zone with top half of main reinforcing steel embedded in sound concrete.	▪ Medium (reduce by one if wide longitudinal crack or spall within anchorage zone).	▪ Other punchouts. ▪ Medium or wide concrete grout key cracks. ▪ Failed girder connectors.
2	▪ Spall within anchorage zone with unsound concrete extending above top half of main reinforcing steel. ▪ Severe loss of section on main bars or stirrup bends (greater than 20%).	▪ Wide or growing (reduce by one if wide longitudinal crack or spall within anchorage zone).	▪ Wide flexural cracks. ▪ End diaphragm spall extending into legs.
1			

Table 7.2 - Rating Guide – Standard Reinforced Concrete Girders

Notes:

- Reduce as needed to reflect condition and functionality of structure.
- Longitudinal crack rating is eligible for a one rating point increase if girder type has hooked or cranked longitudinal bars (Type PA and PG girders only) OR longitudinal cracking or spalling is limited to a single leg on the girder. These rating point increases are not cumulative.
- If defects listed are limited to curb girder only the ratings can be raised by one to reflect the lower live load carrying function of this unit.
- Reduce rating by one for punchouts if punchout occurs at lift hook pockets, connector pockets, or at midspan of girder.
- Anchorage zone defined as 1.2 m from the end of the girder for all spans less than 10 m.
- Anchorage zone defined as 2.0 m from the end of the girder for all spans 10 m or longer.

Cracks Widths:

- Hairline less than 0.1 mm
- Narrow 0.1 mm to less than 0.3 mm
- Medium 0.3 mm to less than 1.0 mm
- Wide equal to or greater than 1.0 mm

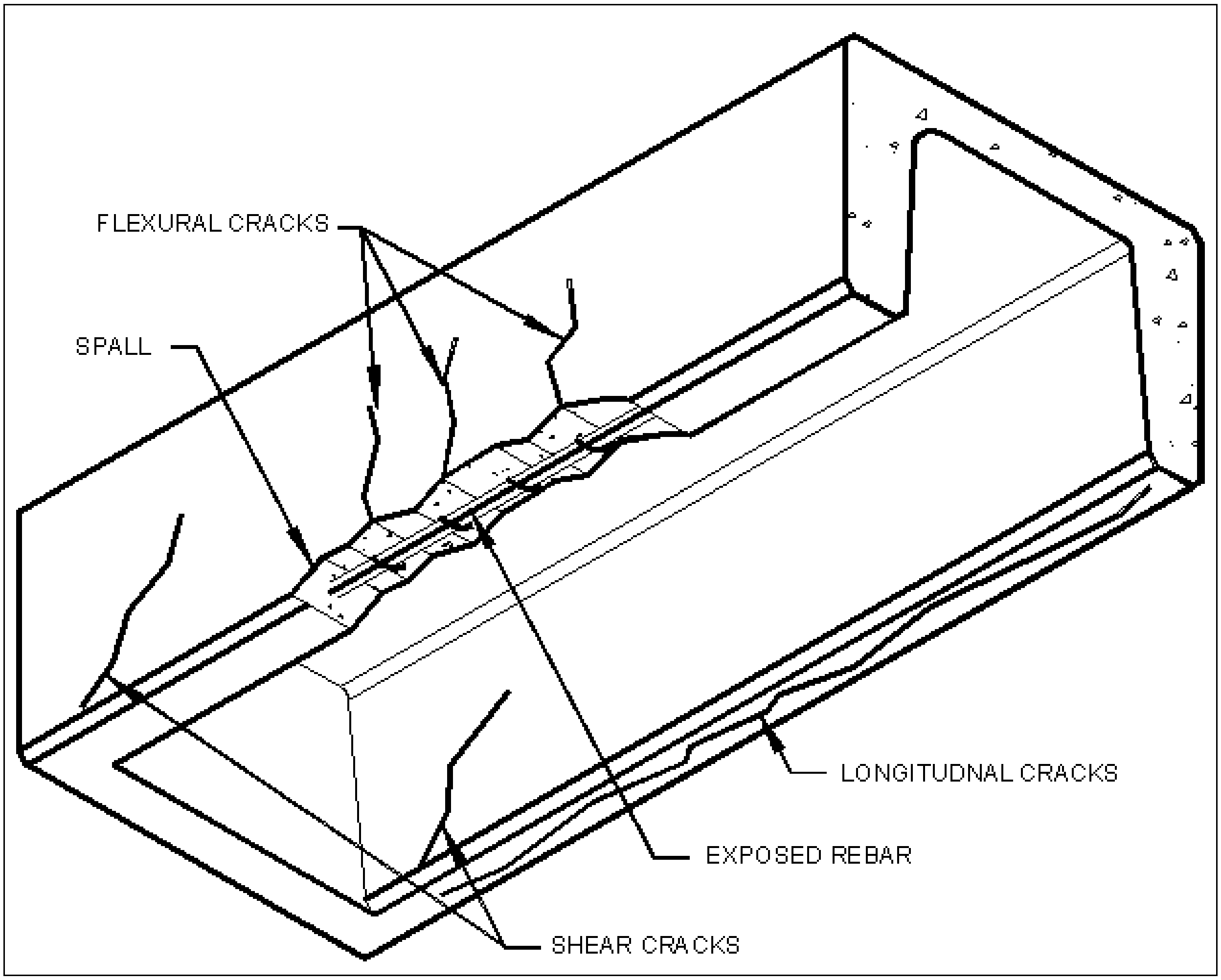


Figure 7.14 - Typical Standard Reinforced Channel Girder with Defects Illustrated

Figure 7.15 - Wide Crack in Anchorage Zone

Figure 7.16 - Spall in Anchorage Zone with Sound Concrete

Figure 7.17 - Spall in Anchorage Zone with Unsound Concrete

7.15.4. Rating Prestressed Concrete Girders

This section covers the criteria for rating prestressed or post-tensioned concrete girders. These girders are normally designed for the concrete to remain in compression under dead and live loads. Structural cracking of these girders is expected to be very minimal. However, because of internal secondary stresses in the girder caused by the prestressing or post-tensioning, there are a number of typical cracks that occur in these girders, particularly at the ends. Also, because the stressing strands are under high tension forces any corrosion of these strands is more significant than for mild steel reinforcement. See Tables 7.2 to 7.7 for summary of rating guidelines for these girders.

7.15.4.1. Rust or Corrosion Spots

Field inspections have recorded a number of situations where corrosion spots are a result of rebar chairs, tie wires or reinforcing bars with minimal or no concrete cover. Generally, these particular rust or corrosion spots have no significant effect on the girder rating. For these rust or corrosion spots to be deemed inconsequential or have no significant effect on the girder rating, no visible cracking may be associated with the spots and the inspector must be confident that the corrosion spots are not originating from prestressing strands. The inspector is required to apply experience and judgment when evaluating the effect of these rust or corrosion spots. These spots typically appear as small rust stained areas on the bottom of girder components.

In the event that the cause of the corrosion spots is questionable or unknown, the inspector should, where practical, attempt to expose the area or recommend exposing the area to determine the cause of the corrosion spot.

7.15.4.2. Criteria for Rating Prestressed Girders

Inspection and Coding Procedures

- Check all girders for cracks.
- Determine whether these cracks are typical cracks as noted in the 'Exception Lists'.
- Cracks not identified on 'Exceptions List' should be rated according to the 'Rating Guide for Prestressed Concrete Girders'.
- Look for evidence of corrosion staining on girders and if possible determine source of corrosion staining.
- Corrosion staining is staining from reinforcing steel or prestressing strands. Water staining or staining from deck drains or bridgerail posts, etc. does not affect the girder rating.
- Rust spots as defined in section 7.15.4.1 do not affect girder rating.

Rating Guidelines

- Hairline cracks with no signs of corrosion staining, rate 4.
- Corrosion stains suspected to be originating from prestressing stands (i.e. along strand lines), rate 3.
- Cracks with signs of corrosion in web or bottom of boxes or flanges (except as noted in the 'Exception Lists'), rate 2.
- Any cracks which are growing, rate 2.
- All other cracks (except as noted in 'Exception Lists'), rate 3.

7.15.4.3. Exception List

Table 7.3 - Rating Guide for Prestressed Concrete Girders contains specific criteria for assigning ratings of 1, 2, 3 and 4. However, exceptions lists have been created to deal with typical cracks and defects found in specific prestressed concrete girder types. The cause and consequence of these cracks and defects have been evaluated and specific ratings have been assigned to them.

Exception lists for various types of prestressed girders are shown in Tables 7.3 to 7.7. The inspector is to ensure that the crack or defect meets the characteristics and criteria shown in the list before applying the exception rating. While many of the exceptions on the list are related to major girder types, the Class B inspectors should review the list and familiarize themselves with the exceptions that apply to standard prestressed concrete girder types.

The NU girders are a relatively new girder type. Some cracking has been showing up in the webs at the ends of these girders. The Department is reviewing these cracks to determine if they are eligible for the exception rating list.

7.15.4.4. Summary of Rating Guide for Prestressed Concrete Girders

Rating	Defects
4	▪ Hairline cracks with no staining except as noted in 'Exception Lists'. ▪ Standard girders with a bearing length less than 75 mm - rate 4 or less.
3	▪ All other cracks except as noted in 'Exception Lists'. ▪ Corrosion stains originating from prestressing strands.
2	▪ Cracks with signs of corrosion in webs or bottoms of boxes or flanges except as noted in 'Exception Lists'. ▪ Any cracks which are growing
1	▪ Any cracks which are opening or closing under traffic or with slippage along the cracks.

Table 7.3 - Rating Guide for Prestressed Concrete Girders

Notes:

- Reduce as needed to reflect condition and functionality of structure.
- See 'Exceptions List' below for description of prestressed girder rating exceptions.
- If defects listed are limited to curb girder only, the ratings can be raised by one to reflect the lower live load carry function of this unit. For span types with wide curb units (Type FC, VF, LF or FM), site specific details regarding the location of the defects with respect to the travel lanes should be taken into consideration before applying the one point increase – e.g. inside leg, exterior leg, shoulder to curb distance, etc.

7.15.4.4.1. Exceptions Lists

Girder Type: All Prestressed Girders

Crack	Rating	Description
1.	6	Narrow map cracks.
	4	Medium or wide map cracking or any map cracking with staining.
2.	3	Vertical crack 50 to 100 mm from end of girder with or without signs of corrosion stains. No further rating reduction to be applied for presence of corrosion stains.

Table 7.4 - Exceptions List – All Prestressed Girders

For all the following typical cracks and defects, unless noted otherwise:

- crack width assumed as narrow
- reduce the rating by 1 point with presence of corrosion staining

Girder Type: FC, VF, FM, LF

Crack	Rating	Description
1.	5	Narrow crack in chamfer between web and flange. May extend into deck underside or web. Generally found near girder end but may also extend to first diaphragm location.
	4	Medium or wide crack in chamfer between web and flange. May extend into deck underside or web. Generally found near girder end but may also extend to first diaphragm location.
2.	5	Hairline or narrow longitudinal crack in bottom half of web at girder end.
	4	Medium or wide longitudinal crack in bottom half of web at girder end.
3.	5	Hairline or narrow longitudinal crack at underside of girder leg at girder end.
	4	Medium or wide longitudinal crack at underside of girder leg at girder end.
4.	5	Diagonal crack in the transition and wide web section of the web at girder end (reduce by 1 if extending into top flange or extending into narrow web section).

Table 7.5 - Exception List - Girder Type: FC, VF, FM, LF

Girder Type: Deck Bulb Tee Girders

Crack	Rating	Description
1.	5	Diagonal crack in the transition and wide web section of the web at girder end (reduce by 1 if extending into top flange or extending into narrow web section).

Table 7.6 - Exception List - Girder Type: Deck Bulb Tee Girder

Girder Type: VS, SM, SC, RD, RM, PM, VM, SL

Crack	Rating	Description
1.	5	Diagonal crack on bottom of girder, not longer than 0.5 m. Crack length must be continuous and not intermittent or staggered. Crack lengths to be measured from the face of the pier cap or abutment seat and along the length of the crack (with no signs of corrosion staining).
	3	Diagonal crack on bottom of girder, not longer than 0.5 m. Crack length must be continuous and not intermittent or staggered. Crack lengths to be measured from the face of the pier cap or abutment seat and along the length of the crack (with signs of corrosion staining).
2.	5	Longitudinal crack on girder underside.
3.	5	Longitudinal crack at lower curb fascia.
4.	5	Crack in poured connection at fascia over piers (RM, RD, SMC, SCC, SCM, SLC).

Table 7.7 - Exception List- Girder Type: VS, SM, SC, RD, RM, PM, VM, SL

Girder Type: PO

Crack	Rating	Description
1.	5	Debonded concrete patch over post-tensioning ducts at girder ends (no signs of corrosion staining).

Table 7.8 - Exception List - Girder Type: PO

Shown below are sketches of some typical prestressed girder cracks. Refer to the 'Exceptions List' for further details and descriptions of other cracks.

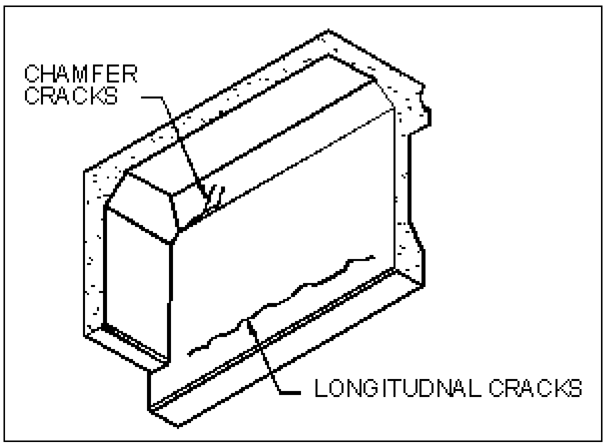


Figure 7.18 - FC Girder Cracks

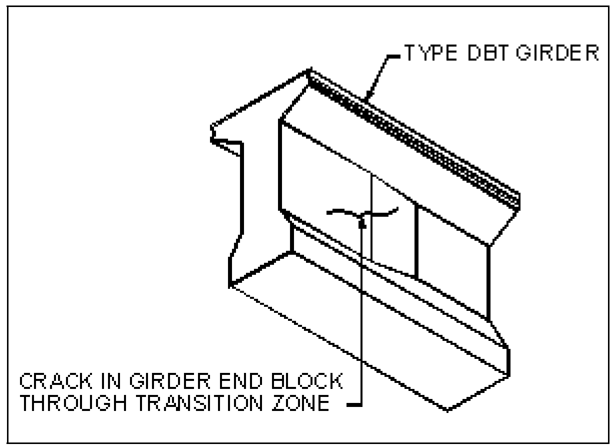


Figure 7.19 - DBT Girder Crack

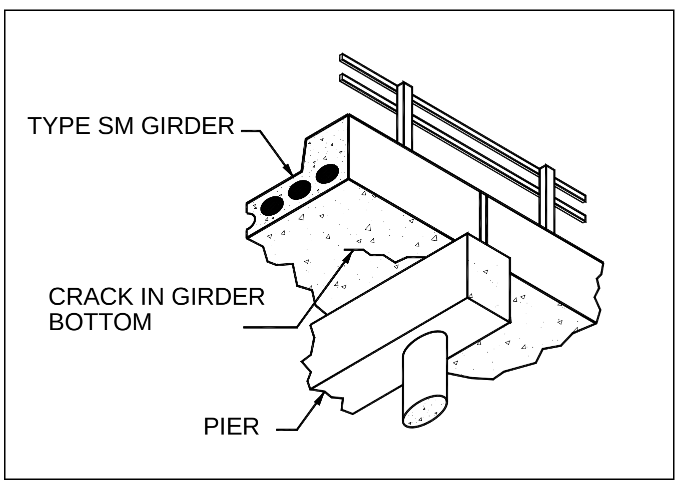


Figure 7.20 - SM Girder Crack

7.16. TRUSS MEMBERS

Bridge Component		Last	Now	Explanation of Condition
Wide Load Damage (Y/N)				
High Load Damage (Y/N)				
Top Chord				
Batter Posts				
Sway Bracings				
Diagonals				
Verticals				
Portals				
Connections				
Floor Beams				
Bottom Chord				

7.16.1. Background

A truss is made up of individual straight members connected to form a series of adjoining triangles. The triangular shape is effective since it cannot be changed without changing the length of its sides.

The common types of truss bridges are:

- Through truss - the deck rests on the bottom chords and traffic goes under the upper bracings
- Pony truss – similar to the through truss, but has much lower top chords and no upper bracings
- Deck truss - the deck is located on the top chords

There are several geometrical configurations used in truss bridges. Under dead load condition, the orientation of the individual members and the variation in cross-sectional areas generally determine the type of stresses (compression or tension) the member was designed to carry. Usually, the top chord is in compression and the bottom chord in tension, similar to a girder.

Howe truss (diagonals slanted up and towards the center) has its vertical members in tension and its diagonals in compression.

Pratt truss (diagonals slanted down and towards the center) has its vertical members in compression and its diagonals in tension.

Quadrangular Warren truss (single vertical at each end and intersecting diagonals) has alternating compression and tension diagonals.

Baltimore truss (Pratt truss with subbars) has members supporting the center of the diagonals and lower chord members.

Camel (Parker) truss is a Pratt truss with top chord on a curve.

7.16.2. Types of Stress in Truss Members

In simple Warren, Baltimore, and Camel trusses, the types of stress in the verticals and diagonals depend on the geometric configuration of the members and the location of the live load. Tension members generally have smaller cross-sectional areas and are susceptible to fatigue factors. Typical tension members are rods, eyebars, and single angles. Compression members, on the other hand, have larger cross-sectional areas, and are susceptible to buckling.

It is recommended that the inspector use the 'method of sections' to determine if or when a member is in tension or compression. The following rule of thumb applies to trusses that are simply supported:

Under Dead Loads

- The top chord is in compression.
- The bottom chord is in tension.
- The batter posts are in compression.
- The first vertical (hanger) from the end is in tension.
- The diagonals located parallel to the batter post for each half of the truss are in compression.
- The diagonals that are not parallel to the batter post for each half of the truss are in tension.
- The verticals, in general, are in compression when the diagonals are in tension and vice versa (except hangers and center verticals). This rule does not apply to trusses with diagonals that intersect each other.

Under Live Loads

- The top chord is in compression.
- The bottom chord is in tension.
- The batter posts are in compression.
- The first vertical (hanger) from the end is in tension.

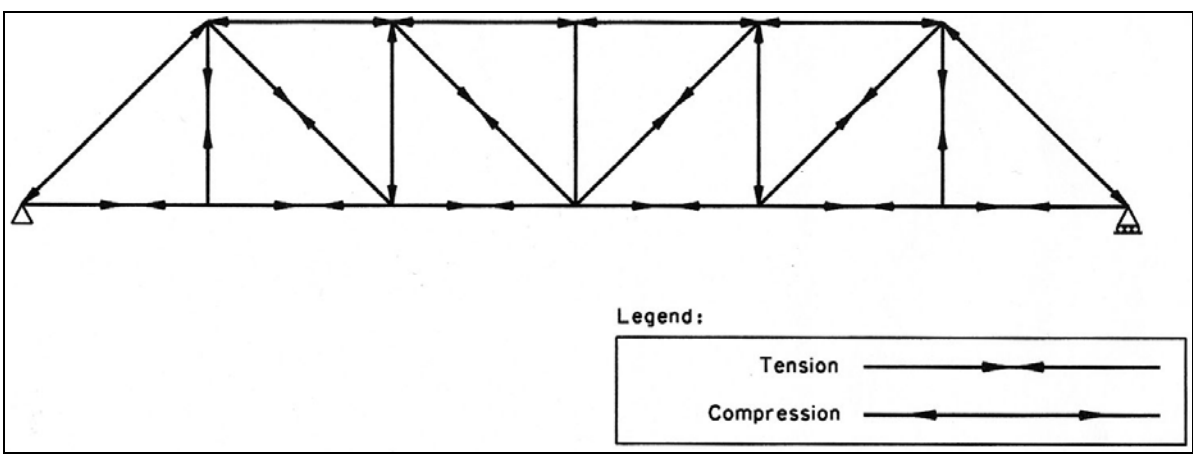


Figure 7.21 - Typical Truss Force Diagram

7.16.3. Truss Member Notation

Truss panel points are numbered from left to right, while looking downstream. The truss member notations shown in Figure 7.22 may be contrary to the span numbering convention (i.e. increasing chainage, south to north and west to east). This numbering system is used because there are numerous historical records that would be too difficult to change to match a revised numbering system.

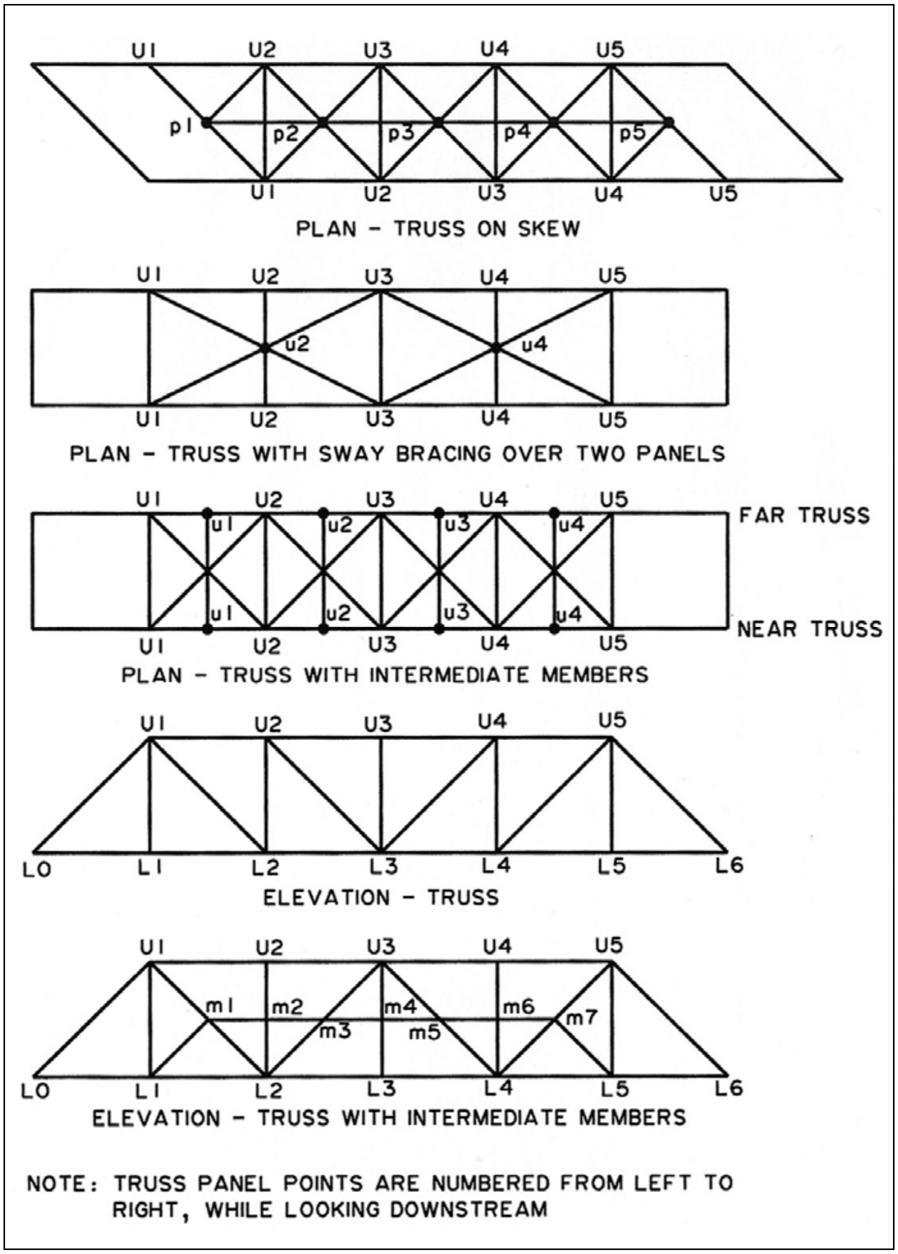


Figure 7.22 - Truss Member Notation

7.16.4. Inspection and Coding Procedures

- Proper labeling convention for truss members is upper panel point to lower panel point (e.g. U4L3).
- Check the alignment of the truss and the individual members. Misalignment indicates overstress, and may result in deflection or buckling, especially in compression members.
- Check all members for deformation, warping, and loss of section caused by rust, especially horizontal members and connections since they are more susceptible to debris accumulation and poor drainage.
- Look for evidence of wide or high load damage and record Y/N.
- Examine batter posts, portal bracings and sway struts for collision damage (see Figure 7.23 and Figure 7.24). Also, note locations and dimensions of damaged members.
- Check tension members and their connections for fatigue cracks.
- Check compression members for kinks or bows (see Figure 7.25). Also, all connections should be intact.
- Check fasteners for missing or rusted rivets, bolts, and nuts. Look for signs of cracked paint which may indicate deformation or tearing. Examine welded connections for cracks.
- Check for lack of movement (frozen) at pinned joints. Main members which require careful inspection are the entire top and bottom chords, diagonals, verticals, and panel points.
- Rate each individual type of member separately.
- Poor paint condition should not influence the rating.
- Pitting or scaling of metal or other losses of section caused by rust should be reason for a lower rating.

7.16.5. Rating Guidelines

- Connections with missing rivets or bolts, rate 4 or less.
- Loss of section, rate 4 or less.
- Wide or high load damage which create stress raisers, rate 4 or less.
- Cracked members, rate 3 or less.

Figure 7.23 - Damaged Batter Post

Figure 7.24 - Damaged Portal Bracing

Figure 7.25 - Sweep in Top Chord

7.17. STEEL GIRDER / BEAM

Bridge Component	Last	Now	Explanation of Condition
Girder/Beam:			
Cover Plate			
Flange			
Web			
Stiffeners			
Splice			
Weld			

7.17.1. Background

The two common types of steel girders are rolled beam and plate girders. The rolled section is usually in the form of an I-beam. The plate girders are also generally I-shaped, consisting of a number of plates (web, flanges, angles, stiffeners, etc.), that are connected by riveting, bolting, or welding.

Both types of girders behave in a similar manner under loading conditions. On simple span bridges, the top flange is placed in compression and the bottom flange in tension. The opposite is true for continuous spans over piers. The web is designed to resist shear, as well as lateral and vertical buckling. Since the maximum shear occurs near piers and abutments, these areas warrant careful inspection. Also, locations of connections or splices are critical due to discontinuity caused by holes or welds.

Plate girders usually have two types of vertical web stiffeners; bearing stiffeners which distribute heavy concentrated loads or reactions to the web and intermediate stiffeners which help prevent buckling due to diagonal compression (similar to stirrups in concrete beams). Stiffeners are sometimes located horizontally in the upper or lower half of the web to help prevent buckling due to high compressive flexural stress. Stiffeners that are welded in tension zones warrant special attention since they may be subjected to fatigue cracks.

7.17.2. Inspection and Coding Procedures

- Check all girder components for corrosion, especially along the top flange, around rivets or bolt head, and bearing areas. In severely corroded areas, measure and record the metal thickness.
- Check all riveted or bolted connections for deformation, warping, rust, tightness, and missing, worn, sheared, or deformed fasteners.
- Check all welds in tension areas for fatigue or corrosion cracks. Details susceptible to cracks are ends of cover plates, stiffeners welded to bottom flange, re-entrant corners, transition areas where the section area changes, stiffener welds that cross the weld from flange to web, any tension zone subjected to excessive vibrations or movement, and corroded areas with high stress concentrations.
- Check web and web stiffeners for signs of buckling, especially at locations of high stress concentrations.

- Look along the girder for evidence of sags, buckling, bowing, and twisting. All connections in the vicinity of distortions must be carefully checked because of the possibility of over stress or eccentricity.
- Examine lower half of the girder for collision damage. Look for dents, nicks, cracks, and tears, as well as damage to connections.
- Rate each girder element separately. Do not include the condition of paint or other protective coating.

7.17.3. Rating Guidelines

- Elements that are structurally sound with no distortion or loss of section, rate 5 or more.
- Any element with corrosion that causes loss of section or pitting, rate 4 or less.
- Any element exhibiting fatigue cracks or showing signs of distortion, rate 4 or less.
- Any element with visible cracks, rate 3 or less.
- Accident damage which create stress raisers, rate 4 or less.
- Any fatigue cracks in the bottom flange that extend into the web, rate 2 or less.

7.18. DIAPHRAGMS / CROSS FRAME

Bridge Component	Last	Now	Explanation of Condition
Diaphragms/Cross Frame			

7.18.1. Background

Diaphragms/cross frames are located between girders or beams to provide stiffness to the system. In some cases, they are designed to distribute loads between members and resist torsion. In general, they are made of materials that are similar to those found in the girders.

7.18.2. Inspection and Coding Procedures

- On timber diaphragms, look for decay, cracking, splitting, and loose connections.
- On concrete diaphragms, look for cracks and spalls.
- On steel diaphragms, look for rust, corrosion, loose connections, cracks at the ends of welds, and misalignment.

7.18.3. Rating Guidelines

- If no cracks or loose connections exist, rate 5 or more.
- Where diaphragms contribute to defects in the girders, rate 4 or less.

7.19. PAINT

Bridge Component		Last	Now	Explanation of Condition
Paint Condition				
(Colour Description :)				
(Colour Code :)				
Touchup Required (Y/N)				

7.19.1. Background

All unprotected steel members eventually rust and corrode in the presence of oxygen and moisture. Corrosion is accelerated in the presence of aggressive ions. To combat the problem, the use of paint, galvanizing, or weathering steel is considered.

Rust is the first phase of corrosion and if allowed to continue, may cause pitting and reduced section area, resulting in significant reduction in load carrying capacity. Also, corrosion in areas of high load concentrations may result in cracks.

Paint or coating condition is rated separately. In the case of weathering steel, check for the formation of the oxide coating, which is initially fine grained and with time becomes flaky or scaly.

7.19.2. Inspection and Coding Procedures

- Check for cracking, chipping, scaling, and rust blisters. Inspect cracks carefully to determine if they penetrate the steel.
- Check for corrosion and loss of section along top flanges, around connections, bearing areas, and all horizontal members on trusses.
- Check for rust, stains, and pitting in areas susceptible to poor deck drainage, or in the case of grade separations, splash from traffic.
- Estimate the percentage of rust or corrosion and provide photographs to support any maintenance recommendations.
- On weathering steel, measure and record the depth and size of any perforations or pitting. Also note their locations and possible cause.
- Record or verify the colour of the top coat. Colour # may be available from BIS data and if so will be recorded on the form. For weathering steel that is not painted, record colour as None.
- If in the opinion of the inspector, touchup paint is required record Y in the field provided.

7.19.3. Rating Guidelines

- If no corrosion exists but some touch-up is required, rate 5 or more.
- If the top coat of painted members is deteriorating but the prime coat is in very good condition, rate 4.
- If there is corrosion which causes significant loss of section in high stress concentration areas, rate 3 or less.

7.20. BEARINGS

Bridge Component		Last	Now	Explanation of Condition
Bearings				
Temperature (deg. C)				
(Expansion Type :)				
(Fixed Type :)				
Functioning (Y/N)				

7.20.1. Background

Bearings are designed to transmit loads to the substructure and permit rotational movement of the superstructure relative to the substructure. Certain types of bearings (expansion) must also permit longitudinal movement due to temperature changes and loading conditions. An effective expansion bearing allows movement with little frictional resistance. In many cases, metal expansion bearings freeze (lock-up) due to corrosion when salt, water, and debris are present. Once the bearing has frozen, high stresses may be induced in the girders, abutments, and piers. The result is generally cracks or spalls in the caps or seats, or tilting of the piers or abutments.

Most bearings consist of:

a) sole plate, which is permanently attached to the bottom of the girder with either nuts, bolts, or welds
b) masonry plate, which is permanently attached to the bridge seat by bolts or cast in concrete
c) devices such as rockers, rollers, pads, or plates located between the sole and masonry plates

7.20.2. Bearing Types

The bearing type, when available, is extracted from BIS and printed on the form. For a specific list of bearing types, see BIS documentation. Common types of bridge bearings are described below:

Neoprene Strip Bearing

This bearing consists of a strip of neoprene material laid on the substructure with the girder placed on top.

Pot Bearing

This bearing consists of a neoprene type material which is confined within a steel ring or pot. If it is an expansion bearing, it will also have a stainless steel plate on Teflon surface to allow for horizontal movement.

Reinforced Neoprene Pad

This bearing consists of a neoprene pad which has been reinforced with steel shims. Small thermal movements can be accommodated with deformation of the pad. However, most expansion bearings of this type will also have a stainless steel plate on Teflon surface for horizontal movement.

Rocker Bearings

This bearing consists of a steel rocker that accommodates thermal movement by rocking of the bearings on a steel masonry plate.

Roller Bearing

This bearing consists of a single steel roller on a steel masonry plate that can move to accommodate thermal movement.

Roller Nest Bearing

This bearing consists of a number of steel rollers that are held together in a steel frame on a steel masonry plate. This roller nest is designed to move as a unit to accommodate thermal movement.

Photos of some of these bearing types can be seen in Figure 7.26 to Figure 7.30.

Figure 7.26 - Rocker Bearing

Figure 7.27 - Roller Bearing

Figure 7.28 - Reinforced Neoprene Pad

Figure 7.29 - Pot Bearing

Figure 7.30 - Roller Nest Bearing

7.20.3. Inspection and Coding Procedures

- Check all steel components for rust, corrosion, sheared bolts, cracked welds, and evidence of frozen bearings or connections.
- Check for debris accumulation that is wedged in slots or other areas which impede movement.
- Check alignment of component parts for proper contact surfaces and minimum resistance.
- Examine elastometric bearings for cracks, splits, and bulging along the edges.
- Check all anchor bolts for firm anchorage by tapping with a hammer. Also look for deformation, freezing, and travel distance of bolts in slotted holes.
- Examine all components of pin and hanger bearings carefully by looking for corrosion, pitting, notches, and cracks. Check the alignment of suspended members. Inspect the pins for wear, looseness, and proper attachment. Ensure wind locks and keys are in place to prevent lateral movement of the girders.
- Look for excessive vibrations or movement under traffic.
- Check bearing pads or bearing plates for creeping out of position.
- Deterioration caused by leaking deck joints or cracks in the caps or seats caused by frozen bearings should be noted.
- Record the air temperature at which the bearing is inspected. Also, note and report all unusual movements.
- Record or verify the type of fixed and expansion joints.
- Note if coating on the bearings is adequate.
- Note whether bearings are functioning as designed (Y/N). If N provide comments.
- Check available travel of rockers, etc. and relate to temperature. Lack of remaining travel may be due to bank encroachment.

7.20.4. Rating Guidelines

- Bearings in excellent condition and functioning but having inadequate coating, rate 7 or 8.
- Bearings that require re-setting, rate 4 or less.
- Frozen bearings which do not function as designed, rate 4 or less.
- For pin and hanger bearings where the hanger is cracked, rate 2 or less. Hangers with signs of corrosion, frozen pins, or missing windlock, etc., rate 3 or less.

7.21. SUBDECK / DECK UNDERSIDE

Bridge Component		Last	Now	Explanation of Condition
Sub Deck/Deck Underside				
(Material Type :)				
(Plank Thickness (mm) :)				
(Plank Width (mm) :)				
Defects (Percent Area)				
Stains (Percent Area)				

7.21.1. Background

The presence of an overlay, debris, or snow may not permit a proper inspection of the Deck Top. The inspection of the Deck Top (section 7.5) and Subdeck/Deck Underside give a complete indication of the overall deck condition. Many areas of impending or existing deterioration or distress can be confirmed by inspecting the underside.

7.21.2. Inspection and Coding Procedures

- Note the type (timber, concrete, or steel) of subdeck or deck underside.
- In the case of timber subdeck, note the nominal width and thickness of the planks. Laminated timber subdecks should also be noted.
- On timber decks look for decay, loose or broken planks, cracks, loose timber clips, and deflection under traffic.
- On concrete decks look for cracks, stains, spalls, scaling, efflorescence, exudation, and deterioration.
- On steel decks, look for corrosion and loose connections.
- Check deck underside in vicinity of joints for leakage.
- For concrete deck, estimate the stained area, in percentage.

7.21.3. Rating Guidelines

- A concrete deck underside with minor cracking or staining, rate 5.
- Rate 4 or less if there is any spalling or severe scaling of concrete.
- Rate 4 or less if there are any signs of decay of timber.

7.22. SPAN ALIGNMENT

Bridge Component	Last	Now	Explanation of Condition
Span Alignment Problems			
Vertical (Y/N)			
Horizontal (Y/N)			

7.22.1. Background

This item applies only to the horizontal and vertical alignment of the superstructure (see Figure 7.31 and Figure 7.32). A rating of alignment problems is not required.

Most misalignments are indicative of distress in the superstructure, substructure, or both.

7.22.2. Inspection and Coding Procedures

- Look along the edges of the girders, top and bottom chords of trusses, curbs and handrails, for signs of sags, bows, movement, buckling, twisting, or other signs of irregularities.
- Look for unevenness at the deck joints.
- Examine each expansion gap for uneven openings.
- Look for twisting of a structure due to skew pressures.
- Look for structures that do not fit the horizontal or vertical alignments.
- Note all alignment problems. Include their locations and possible causes.

Figure 7.31 - Horizontal Misalignment

Figure 7.32 - Vertical Misalignment

7.23. SUPERSTRUCTURE GENERAL RATING

The superstructure general rating is governed by:

- ratings for structural load carrying elements
- subdeck or deck underside rating
- girder or stringer rating
- safety concerns (missing bridgerail section, severe span alignment problems, severe bumps, etc.)
- a missing bridgerail that is rated X may govern general rating if it creates a hazardous situation (i.e. rate 2)

8. CHAPTER 8 - SUBSTRUCTURE

8.1. INTRODUCTION

The substructure consists of all bridge elements that receive loads from the superstructure and the approach embankments. The integrity of the superstructure depends on its ability to transmit vertical and horizontal forces to the underlying soil without causing significant movement or deformation. A proper substructure inspection must consider the effects of the surrounding soil. In general, most substructure problems are caused by overloads, deterioration, non-functional bearings, lateral displacement, or settlement.

Like the superstructure, the substructure is usually made up of one or more of the following materials: timber, concrete, and steel. Refer to section 7.1 of the BIM Inspection Manual and Chapters 1, 2 and 3 of the BIM Reference Manual for more details.

The substructure consists of abutments and piers. They are designed to accommodate loads due to:

a) traffic
b) dead load of the superstructure
c) approach embankments
d) impact caused by debris, ice, water, or collision
e) longitudinal load caused by braking of heavy vehicles
f) expansion and contraction during temperature changes
g) buoyancy when located in streams
h) lateral loads transferred from the superstructure (i.e. wind load)

Inspectors must be familiar with the substructure terminology shown on the form and be able to assign ratings to the correct elements. When the element is not visible and a rating cannot be assigned, the element is rated N.

8.2. ABUTMENTS

Abutments provide support at the ends of bridges, and unlike piers, are sometimes designed to retain the approach embankments. The three major types of abutments, classified according to the ratio of their height and the bridge height, are:

a) **Full height or closed**: These are usually solid retaining walls that extend for the full height of the bridge with no or minimal headslope. They are susceptible to lateral displacement and scour at the bottom of the breastwall during floods.
b) **Spill-through**: These are abutment caps that intersect the headslopes. They are susceptible to scour/erosion at the toe of the headslope and slumping of the headslope.
c) **Stub**: These are either downward extensions of the abutment cap or a combination of the cap and a backwall that usually does not extend beyond mid-height of the bridge.

Pictures of full height and spill through abutments are shown below.

Figure 8.1 - Full Height Abutment

Figure 8.2 - Spill-through Abutment

8.3. PIERS

Piers are located between the abutments on multi-span bridges to support the super-structure. The three major types of piers are:

a) **Solid Pier**: The width from top to bottom closely matches the width of the bridge, and is either made of concrete or two rows of timber or steel piles that are sheathed on both sides.
b) **Pile Bent**: It consists of two or more piles or columns that are connected at the top with a cap.
c) **Cantilever Pier**: Usually constructed of concrete with a single column supporting an overhanging cap.

8.4. EXTENDED BACKWALL PILES

Bridge Component	Last	Now	Explanation of Condition
Abutments			
Extended Backwall Piles (Y/N):			
Extended Backwall Piles Spacing (m):			

8.4.1. Background

An extended backwall pile is a pile on the same line as the backwall bearing piles but located beyond the abutment cap. Its purpose in the original design was to support the backwall but it may be used as a bearing pile if the bridge is widened in the future. A rating of extended backwall piles is not required.

8.4.2. Inspection and Coding Procedures

Note whether the abutment has extended backwall piles (Y/N) and record the maximum spacing of the extended piles to the nearest tenth of a metre.

Note any problems or deficiencies in the extended backwall piles in 'Explanation of Condition'.

8.5. ABUTMENT AND PIER BEARING SEATS / CAPS / CORBELS

Bridge Component				Last	Now	Explanation of Condition
Abutments or Piers/Bent						
(Total Number of Caps or Corbels)						
Bearing Seats/Caps/Corbels Detail Rating						
	N (count)	1 (count)	2 (count)	3 (count)		
Last						
Now						
Bearing Seats/Caps/Corbels						
(Type:)						
(Depth (mm) :)						
(Width (mm) :)						

8.5.1. Background

These elements receive loads from the superstructure and distribute them to the piles, columns, or shafts below. These loads, when transmitted through bearings, may result in high stress concentrations in the vicinity of the bearings. As such, these areas should be carefully examined for cracks, spalls, corrosion, or signs of crushing.

This element may be constructed using treated timber, reinforced concrete, or steel. Timber caps are generally found on timber pile bents. Concrete caps are found on either concrete or steel piers and abutments. Steel caps are usually found on steel or timber piers and abutments. Corbels are located between the bridge bearings and the caps, and are either timber or steel and are normally found in truss bridge structures.

This section refers to bearing seats/caps/corbels for both abutment and piers and the instructions and procedures apply to both. However, the bearing seats/caps/corbels for abutments and piers have separate locations on the form and the information and rating for each are recorded separately.

Photos of some common defects in timber caps and corbels are shown in Figure 8.3 to Figure 8.7.

8.5.2. Inspection and Coding Procedures

- Look for good contact and adequate bearing areas between the girders or bridge bearings and the bridge seat, caps, or corbels. The same applies to the interface

- between the caps/corbels and the piles. Note any gaps or uneven bearing surfaces.
- Check for evidence of loose connections or corrosion of drift pins.
- Check for rotation or displacement of caps or corbels. This usually indicates sub-structure movement, caused by high lateral pressure of the soil.
- Check bearing seats/caps for dampness or ponding and debris accumulation caused by open or leaking joints.
- Check all timber caps and corbels for decay, especially in areas susceptible to moisture accumulation and constant wetting and drying. Typical areas are the interface between the girders or piles and the cap, around dowels or bolt holes, and at the ends. Coring may be required to determine if rot is present in the caps and corbels. All core holes used for inspection must be filled with suitable plugs. Coring of timber is generally carried out with a Level 2 inspection.
- Examine all timber caps and corbels for splitting, crushing, bulging or cracking. Check for evidence of crushing at the interfaces between girders or piles and the caps or corbels.
- Check concrete seats/caps for cracks, spalls, corrosion of reinforcement, and disintegration of the concrete.
- Check steel caps for corrosion and cracks at welds, especially at connections. Look for bending and deformation of the web and flanges.
- Check keeper plates on the bearing seat.
- Note if file tag is missing.
- Record or confirm the type of bearing seat, cap, or corbel.
- Record or confirm the width and depth of the caps and corbels using nominal dimensions (i.e. 305x305 mm or 305x356 mm).
- Record the total number of individual pieces of abutment caps, subcaps and corbels in structure (both abutments).
- Record the total number of individual pieces of pier caps, subcaps and corbels in structure (all piers).

8.5.3. Rating Guidelines

- Timber caps/corbels with vertical or horizontal cracks extending through the full depth of the caps, rate 4 or less.
- Timber caps/corbels with signs of crushing, rate 2 or less.
- Caps/corbels with signs of bulging, rate 3 or less.
- Caps with a girder bearing length less than 100 mm, rate 4 or less.
- Caps with a girder bearing length less than 75 mm, rate 3 or less.
- Any deficiencies that would reduce the ability of these elements to transmit loads, rate 4 or less.

- If a treated timber element is found to have a cut end without any protective coating applied, the timber element itself may be rated down. The lack of a protective coating will expose the untreated timber interior to moisture and potential rot.

8.5.4. Caps/Corbels Detail Ratings

For timber caps and corbels, quantified inspection data is gathered if the caps or corbels are rated 3 or less. In the fields provided, record the number of individual pieces of caps and corbels that are rated N, 1, 2, and 3. If the bearing seats/caps/corbels element field is rated 4 or above, based on worst condition, the detail rating fields should be recorded as 0 (zero). If caps and corbels are not timber, the detail rating fields should be recorded as 0 (zero).

Figure 8.3 - Rot in Timber Cap

Figure 8.4 - Insufficient Bearing

Figure 8.5 - Bulging of Timber Cap

Figure 8.6 - Crushing of Timber Cap

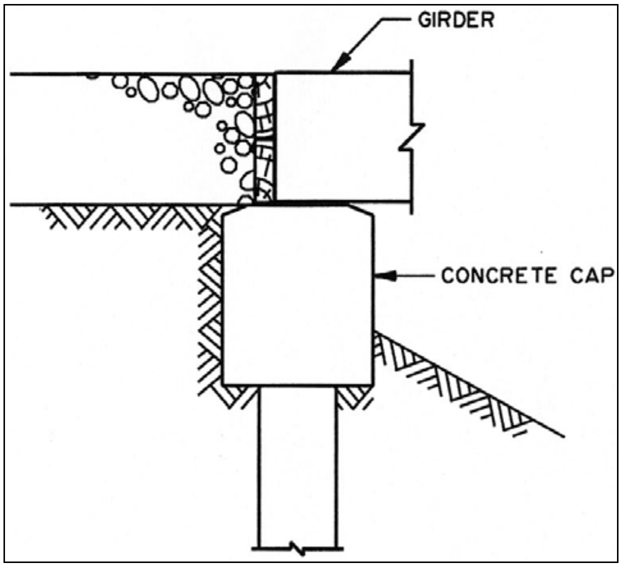
Figure 8.7 - Timber Cap Rotating

8.6. BACKWALLS / BREASTWALLS

Bridge Component		Last	Now	Explanation of Condition
Abutments				
Backwalls/Breastwalls				
Greatest Height (m)				

8.6.1. Background

The portion of the abutment between the wingwalls makes up the backwall and breast-wall, which are located above and below the bearing seats/caps/corbels respectively. Their main function is to act as retaining walls for the approach embankments. In some cases, especially for concrete abutments, the backwall is also designed to support the approach slab and the breastwall is designed to transmit vertical and lateral loads to the foundation. The following sketches show some typical abutment elements.



The sketch at the left shows a standard concrete abutment with a concrete cap on steel piles. The element is rated as a concrete cap. The backwalls/breastwalls rating is recorded as X.

Figure 8.8 - Standard Concrete Abutment (Typical)

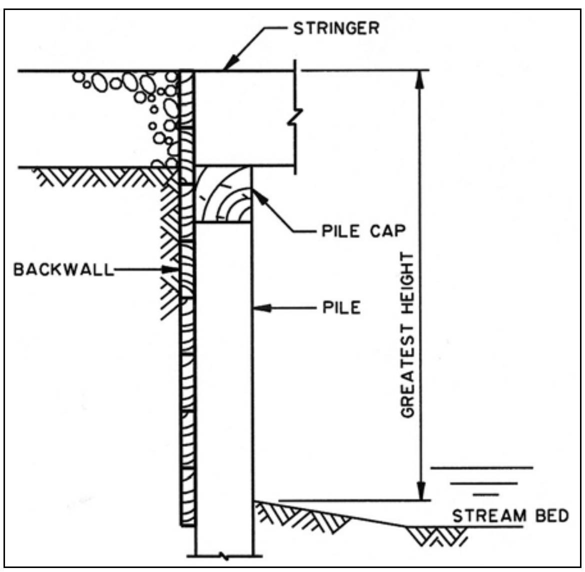


Figure 8.9 - Timber Abutment (Typical)

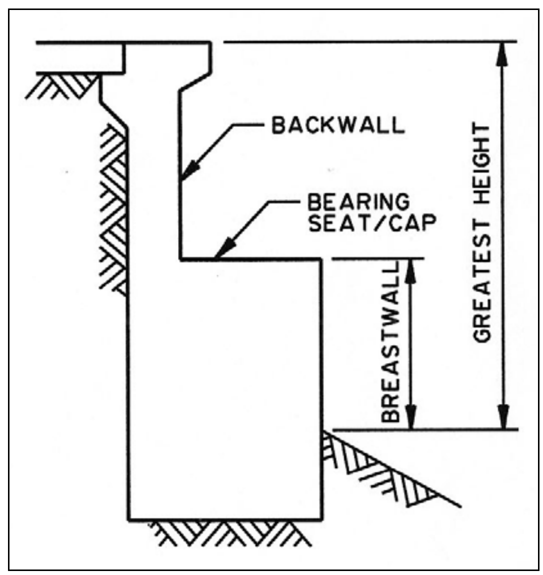


Figure 8.10 - Concrete Abutment

8.6.2. Inspection and Coding Procedures

- The rating of these elements should consider their condition and ability to retain the approach fill. Stability, and scour caused by approach drainage or stream flows are rated separately in section 8.10 Abutment / Pier Stability and section 8.11 Scour / Erosion.
- Note any significant loss of material below the backwall/breastwall that is due to insufficient backwall/breastwall depth and not necessarily by scour/erosion (i.e. backwall/breastwall does not extend low enough). See Figure 8.11.
- Examine the gap between the backwall and the girders to ensure there is enough space for movement. This does not apply to standard timber and precast bridges where the backwall planks are tight against the girders.
- On timber backwall/breastwall, note the condition of the sheathing only. Look for decay, cracks, missing or bowing planks, sloping planks, or loose connections. Note any significant loss of embankment material between planks.
- Determine if backwall/breastwall scabs are functioning properly. See Figure 8.12 for sketch of backwall scab.
- Check concrete backwall/breastwall for cracks, spalls, general disintegration, and whether drains and weep holes are functioning properly.
- Check steel backwall/breastwall for corrosion and loose connections.
- Measure and record the maximum combined height of the backwall/breastwall, measured from the top of the bridge deck to the ground level adjacent to the abutment at the location of the greatest height. This measurement is usually obtained by measuring the greatest height from the ground/headslope to the underside of the girders and adding the depth of the girders, subdeck and wearing surface.

8.6.3. Rating Guidelines

- If there is loss of material below the backwall or breastwall, rate 4 or less.
- If there is decay in sheathing or missing planks, rate 4 or less.

Figure 8.11 - Backwall Sheeting Needs Lowering

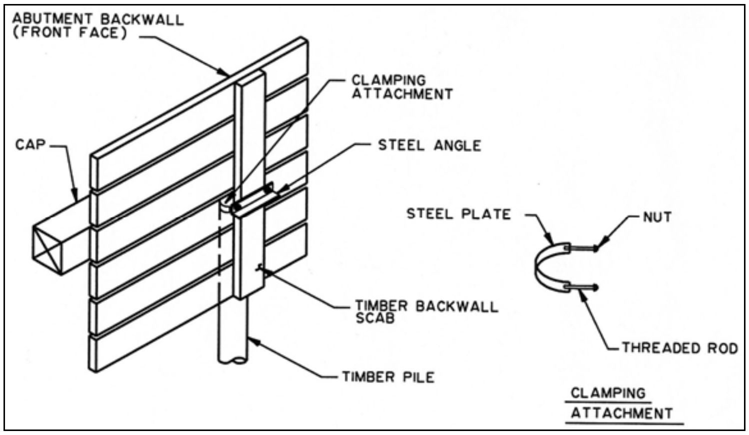


Figure 8.12 - Typical Backwall Scabs

8.7. WINGWALLS

Bridge Component	Last	Now	Explanation of Condition
Wingwalls			

8.7.1. Background

Wingwalls are located on both sides of the backwall/breastwall at each abutment. Their primary function is to retain the embankment material. Curtain walls are to be rated with wingwalls.

The condition rating should include the condition of all supporting piles and connections. Stability and scour/erosion are rated separately in section 8.10 Abutment / Pier Stability and section 8.11 Scour / Erosion.

8.7.2. Inspection and Coding Procedures

- Check condition of all connections and supporting piles.
- Check timber wingwalls for decay, cracks, splits, bulging, and missing planks.
- Check concrete wingwalls for spalls, cracks, and disintegration of concrete.
- Check steel wingwalls for bulging, buckling, and loss of section due to corrosion.
- Look for heaving of wingwall piles, and check the alignment of the wingwalls.
- Look for missing tin tops, broken tie-bands and unsecured backwall cleats.

8.7.3. Rating Guidelines

- Wingwalls that are functional but require repairs for aesthetics, rate 5.
- Wingwalls requiring repairs to be functional, rate 4 or less.

8.8. ABUTMENT BEARING PILES AND PIER SHAFT / PILES

<table>
<tr><td colspan="5">Bridge Component</td><td>Last</td><td>Now</td><td>Explanation of Condition</td></tr>
<tr><td colspan="7">(Total Number of Bearing Piles :)</td><td rowspan="7"></td></tr>
<tr><td colspan="7">Piles Detail Rating</td></tr>
<tr><td></td><td>N (count)</td><td colspan="2">1 (count)</td><td>2 (count)</td><td colspan="2">3 (count)</td></tr>
<tr><td>Last</td><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td>Now</td><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="5">Abutment Piles or Pier Shaft/Piles</td><td></td><td></td></tr>
<tr><td colspan="3">Greatest Height (m)</td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

8.8.1. Background

The information in this section is applicable to abutment bearing piles and pier shafts and associated bearing piles. Note that the pier shaft/piles and the abutment piles are rated separately.

Pier shaft is that portion of the pier that extends from the cap down to the footing or foundation piles. They include all types of piers including pile bents.

Piles are usually the last bridge element which transmits loads to the surrounding soil. Although their main function is to transmit vertical loads, they are also designed to accommodate lateral loads.

Photos of some common defects in timber piles are shown in Figure 8.13 to Figure 8.15.

8.8.2. Inspection and Coding Procedures

- Check the pier shafts of all grade separation bridges for collision damage.
- Check the pier shaft of all stream bridges for impact damage due to ice or debris.
- Check pier shafts/piles and abutment piles for deterioration near the low water line and at the ground line.
- Check for deterioration of all areas that are exposed to splash from vehicles, or moisture from leaking joints or the deck drainage system.
- Check for bowing and misalignment of piles due to deterioration, impact, excessive loads or unintended lateral loading (e.g. migration of concrete headslope against piles on a grade separation).
- Check piles for signs of heaving or settlement.
- Examine timber piles for decay, crushing, and splitting, especially in the vicinity of the pile cap and around holes used for attachments, at ground lines, and at low water line.
- Examine concrete elements for cracks, spalls, and efflorescence, especially in the vicinity of frozen bearings and leaking joints.
- Examine steel elements for loss of section due to corrosion, cracks at welds, and defective connections.

- The condition rating should not include scour/erosion and stability. These are rated elsewhere.
- Record the number of bearing piles at both abutments and in all pier bents.
- Note the greatest height of the pier or pier bent. Measurement should be taken from the top of the pier to the streambed at the location of the greatest height.
- Note the repair requirements of the visible piles.
- Note if the piles are heaving or settling.

8.8.3. Rating Guidelines

- Pile bents/piles that are not sharing the loads from the superstructure, rate 4 or less.
- Piles showing duress (e.g. bowing), under loads, rate 2 or less.
- Timber piles with wide splits or cracks, rate 4 or less.
- Timber piles with repairs to splits or vertical cracks (bands/clamps/struts/backwall scab), rate 5.
- Timber piles with horizontal cracks due to bending, rate 3 or less.
- Timber piles with crushing at the point of horizontal loading of struts, rate 3 or less.
- Timber piles with bulging of the outer fibers, rate 2 or less.

8.8.4. Timber Bearing Piles Detail Ratings

For timber bearing piles, quantified inspection data is to be gathered if the piles are rated 3 or less. In the fields provided, record the number of bearing piles that are rated N, 1, 2, or 3. If the bearing piles element field is rated 4 or above, based on worst condition, the detailed rating fields should be recorded as 0 (zero). If the bearing piles are not timber, the detailed rating fields should also be recorded as 0 (zero).

Figure 8.13 - Split Timber Pile

Figure 8.14 - Checks in Timber Pile

Figure 8.15 - Rot in Timber Pile

8.9. PAINT / COATING

Bridge Component	Last	Now	Explanation of Condition
Paint/Coating			
(Colour Description :)			
(Colour Code :)			

8.9.1. Background

The paint/coating is rated separately for abutments and piers. Paint is usually applied to steel, while other coating systems are used on concrete. The main function of these paint/coating systems is to prevent moisture from reaching the structural element, thus protecting it from deterioration.

8.9.2. Inspection and Coding Procedures

- Check all areas, especially those susceptible to constant exposure to deck drainage, and around connections such as bolts and rivets.
- Check for cracking, peeling, and exposure of the structural element or prime coat.
- Look for rust blisters and discoloration.
- The rating should include the condition of the paint/coating system and its effectiveness to protect the structural element.
- Record the colour of the existing coating of steel pier elements where applicable.

8.9.3. Rating Guidelines

- On standard timber substructures, the paint/coating rating applies to the coating on steel nose plates only. Creosote or other preservatives on timber are not considered a coating. On concrete substructures, only rate visible coatings such as paint or sealers that are applied to the concrete surfaces. Otherwise rate X.
- If top coat is deteriorating, but prime coat is intact, rate 5.
- If some pitting and/or loss of section is present, rate 4 or less.
- Coatings used for aesthetics only, rate 3 or more.
- If no coating exists on steel elements and there is corrosion, rate 4 or less.

8.10. ABUTMENT / PIER STABILITY

Bridge Component	Last	Now	Explanation of Condition
Abutment Stability or Pier Stability			

8.10.1. Background

The stability of the abutments and piers is rated separately. Instability of the substructure may cause failure of the structure or problems with certain superstructure components.

Instability of abutments and piers can be categorized as:

a) rotational or dipping: caused by excessive earth pressure, scour/erosion at the toe of spread footing, slides, frozen bearings, or superstructure movements
b) vertical movement: can be either heave caused by frost, ice, or expansive clays; or settlement (uniform and differential) due to scour/erosion under footings, or inadequate bearing capacity
c) horizontal movement or sliding: caused by movement of the soil mass or slope failure

In general, small movements in the substructure are expected and are tolerable. However, any movement that adversely affects the load carrying capacity or level of service, or causes distress to bridge elements is considered excessive.

8.10.2. Inspection and Coding Procedures

- Look for rotational movement by checking clearance between the ends of girders and backwall, vertical misalignment of caps/corbels with the breastwall or pier shafts, damage to bearings and anchoring system, scour/erosion at the toe of footings, and signs of embankment movement.
- Look for lateral movement by checking unusual displacement at the bearings, uneven bearing areas, horizontal misalignment between spans, uneven gap in deck joints, separation between backwall/breastwall and wingwalls, signs of embankment movement, and out of plumb pier shafts/piles.
- Look for vertical movement by checking for unevenness on the deck, curbs, and handrails in the vicinity of joints; cracks in the superstructure, scour/erosion under footings, and defective piles under caps or pier shafts.
- Note elements that provide abutment stability in the 'Explanation of Condition' (i.e. struts, backwall scabs, etc.). Identify any deficiencies in these elements that suggest the instability is continuing (e.g. bowed struts, sheared or broken backwall scab clamps, etc.).
- If there are movements of an abutment or pier that should be monitored, the inspector should identify a reference point and take measurements that can be checked during the next inspection.

8.10.3. Rating Guidelines

- Movement that causes damage to any load transmitting component of the bridge, rate 4 or less.
- Movement that requires monitoring, rate 4 or less. Establish reference point and measurement for next inspection cycle.

8.11. Scour / Erosion

Bridge Component	Last	Now	Explanation of Condition
Abutment Scour/Erosion, or Piers Scour			

8.11.1. Background

Scour/erosion is rated separately for abutments and piers. For the purpose of the manual, scour is defined as localized erosion caused by constrictions or obstructions, where as erosion is defined as the general removal of material from the stream banks and bed by flowing water. Erosion can be caused by stream flow but erosion can also be caused by drainage from the bridge, approach road and ditches. Scour at bridge crossings occurs around abutments, piers, and river training works. Factors affecting scour include stream geometry, type of material on stream banks and bed, obstructions such as ice and debris, geometry and alignment of abutments and piers, degree of constrictions at the crossing, and the severity of the flood. Scour measurements may be necessary in order to provide a proper rating.

The Substructure section of the form provides two locations to rate scour and erosion. Scour/erosion that affects the abutment is to be rated under scour/erosion for the abutment. Scour that affects the pier is to be rated under the pier scour rating. Scour that affects neither the abutment nor the pier is not rated under the Substructure section of the form. This scour or erosion can be considered under the Channel section of the form if the scour affects an element there.

8.11.2. Inspection and Coding Procedures

- Determine the extent of scour/erosion at abutments and piers as related to the substructure stability.
- Try to determine the probable cause of the scour/erosion (e.g. drift accumulation, channel migration, etc.).
- At abutments, look for undermining or loss of material from under or behind the abutment.
- At piers, look for loss of material under footings, debris accumulation under footings, and at the pier shaft or piles.
- General stream degradation due to change of land use, etc., and slumping banks under the bridge should be considered in this rating. Rating should not include debris accumulation.

8.11.3. Rating Guidelines

- Drainage problems are rated under the approach road section but if it is causing erosion that affects the abutment, it should also affect the abutment scour/erosion rating.
- Scour/erosion that threatens the stability of the substructure, rate 3 or less.
- Abutment scour/erosion that causes loss of material from below or behind the abutment, rate 4 or less.

- Erosion at the abutment that leaves an almost vertical bank under the bridge, rate 3 or less.

8.12. BRACING / STRUTS / SHEATHING

Bridge Component	Last	Now	Explanation of Condition
Bracing/Struts/Sheathing			

8.12.1. Background

This element pertains to piers only, except for struts which may span between a pier and the abutment or between abutments.

Bracing is used on pile bents for load distribution and rigidity. Sheathing is mostly used in timber pile bents. They contribute to load distribution and rigidity, and are sometimes used to confine backfill material and prevent drift accumulation between the piles. On timber pile bents, the sheathing may form a solid wall on both sides and extends from the pile cap down to streambed level. Struts may also be used in timber substructures to add longitudinal stability.

8.12.2. Inspection and Coding Procedures

- Check all connections for deterioration.
- Check timber members for decay, splitting, and missing pieces.
- Check steel members for loss of section and cracks at welds.
- The rating of struts should include the scabs. Determine if struts interfere with the passage of drift.
- Bracing, struts, and sheathing on a bridge are given a single combined rating. Use the ‘Explanation of Condition’ column to note details.
- The rating should include the overall condition and its ability to function as intended.
- Struts that are bowed indicate substructure movement and as such must be noted.

8.12.3. Rating Guidelines

- Cracked or broken bracing, rate 4 or less.
- Loose or missing sheathing, rate 4 or less.
- Missing or broken strut(s), rate 3.

8.13. NOSE PLATE

Bridge Component	Last	Now	Explanation of Condition
Nose Plate			

8.13.1. Background

Nose plates are located on the upstream side of piers or pier bents to protect them from impact damage caused by ice and debris. They are usually made of steel.

8.13.2. Inspection and Coding Procedures

- Look for impact damage above the plates and note if the nose plates are not high enough. Impact damage on the pier should be rated under pier shaft/piles, section 8.8 Abutment Bearing Piles and Pier Shaft / Piles.
- Look for loose connections or missing portions of the plate.
- Check for loss of section due to corrosion.

8.13.3. Rating Guidelines

- A missing nose plate on a timber pier that is susceptible to ice damage, rate 3 or less.
- If there is no nose plate rate X and, if in the opinion of the inspector one is required, make a recommendation to install one in ‘Explanation of Condition’ and on last page of form.

8.14. DEBRIS

Bridge Component		Last	Now	Explanation of Condition
Debris (Y/N)				

8.14.1. Background

For the purpose of this manual, debris is defined as material transported by the stream. It includes uprooted trees and vegetation, logs, boulders, beaver dams and refuse foreign to the watercourse. If not removed, they can cause serious problems such as scour/erosion, blockage of the waterway opening, impeding fish passage, and upstream siltation.

8.14.2. Inspection and Coding Procedures

- Look at the upstream and downstream sides of the piers for debris accumulation.
- Debris accumulation located away from the bridge but is having significant effect on the bridge is noted under section 9.2 Channel.
- If debris exists at the bridge, note its location and effects on the bridge in ‘Explanation of Condition’ column.
- Old piling under a bridge is considered to be debris. The existence of the piling should be noted in the ‘Explanation of Condition’ and Y should be entered for debris.

8.15. GENERAL RATING

The substructure general rating is governed by:

- ratings for structural load carrying elements
- bearing seat or cap rating
- pile rating
- backwall rating of 2 or less
- stability rating

The element ratings for both abutment and pier must be taken into account when assigning the overall substructure general rating.

9. CHAPTER 9 – CHANNEL - BRIDGES

9.1. INTRODUCTION

This chapter is applicable only to bridges on watercourses. This section of the BIM report is replaced with another section whenever the bridges are used as grade separations or as pedestrian overpasses (see Chapter 10). The channel section for culverts is covered in chapter 13.

Bridge crossings are designed to meet several constraints and as such may not be ideally located from a river engineering point of view. In these situations, innovative techniques are used to make the crossing feasible. However, due to the relatively high cost of these techniques, the designer may have to compromise to achieve a design that is economical and safe, but requires maintenance after significant flood events.

One of the factors that affect the integrity of a bridge is the preservation of the supporting soil around the substructure. The supporting material is usually under constant threat of removal by stream flows. All streams have inherent dynamic qualities that tend to change their position and geometry. A bridge crossing generally limits these changes and forces the stream to make other adjustments at or in the vicinity of the bridge. Some of the changes that can occur are bank migration, aggradations, degradation, scour, and flow re-alignment. These changes can be aggravated by constriction, debris accumulation, channel re-alignment, and hydraulic control structures. It is important that the inspector recognizes the impact of these changes in order to provide proper ratings and maintenance recommendations. Any prior knowledge of the stream and the crossing, as well as the land use within the drainage basin would be helpful to the inspector.

In addition to the routine inspection, all bridges should be inspected during and after a significant flood event.

9.2. CHANNEL

Component		Last	Now	Explanation of Condition
Channel				
(U/S Direction :)				
(D/S Direction :)				
Alignment				
Bank Stability				
HWM (m below top of curb)				
Drift (Y/N)				

9.2.1. Background

This section refers to the portion of the channel reach, upstream and downstream of the bridge that affects the alignment of the flow and/or threatens the stability of the bridge or the area surrounding the bridge.

The channel alignment rating is based on the direction of the flow during significant flood events relative to the orientation of the piers and abutments. Substructures which are properly aligned with the flow generally minimize ice forces and ice jam formation, drift accumulation, backwater effects, scour/erosion, and the contraction effects on the waterway area.

Stable stream banks usually help to maintain the alignment of the flow. Bank instability is caused by channel migration resulting in undercutting of the toe and/or degradation of the streambed. If bank migration continues, especially on the upstream side of the bridge, then the approach fills and the abutments may be subjected to continuous attack.

The high water mark (HWM) is a measurement of the highest recorded water level below top of curb and may be obtained by the inspector while at the site. This measurement is a valuable record, used to monitor current conditions and to aid in the design of future replacement structures. High water marks are easiest to determine after significant floods. They are not intended to be a record of the normal flow conditions.

In the earlier versions of this manual the high water level was measured from streambed. In this version the high water mark is measured below top of curb. This change was made to reference the high water mark to a fixed elevation since the streambed elevation can change.

9.2.2. Inspection and Coding Procedures

- Record the direction of upstream and downstream (e.g. North and South).
- Look for evidence of channel degradation which may be caused by changes in land use, stream diversion or other modifications and stream control works.
- Look for evidence of scour/erosion along the banks, and at abutments and piers.
- Look for drift accumulation at the bridge and trees leaning or falling into the channel.
- Note the maximum high water mark at or in vicinity of the bridge (in metres) below top of curb elevation. Inspector should note location along curb to which the HWM is measured in the ‘Explanation of Condition’.
- If no HWM is found and no previous mark is recorded, a comment must be provided in the ‘Explanation of Condition’ indicating "No HWM visible." If a previous HWM is recorded and there is no evidence of a new mark, the previous HWM is retained with the date the measurement originated, in the ‘Explanation of Condition’.
- Previous HWMs that were measured above streambed will not appear on the inspection form. If there is a previous HWM recorded it will have been measured from the top of curb.
- If significant amount of drift exists in the channel, note Y and provide a comment in the ‘Explanation of Condition’.

9.2.3. Rating Guidelines

- If the abutments and piers are aligned with the flow, rate 8 or 9.
- If flow impinges on the piers and abutments at an angle and causes local scour, drift accumulation, etc., rate 4 or less.
- If stream banks are unstable in the vicinity of the structure, rate 4 or less.

9.3. SLOPE PROTECTION

Component	Last	Now	Explanation of Condition
Slope Protection			
(Type :)			

9.3.1. Background

This item rates the effectiveness of scour/erosion protection systems used at headslopes.

Scour/erosion usually occurs at the upstream end of abutments, and along the toe of headslopes and full-height abutments. Protection systems commonly used at stub or spill-through abutments are revetments of either concrete slabs, concrete blocks, concrete sacks, heavy rock rip-rap, or gabions. At full-height abutments, the toe of the breastwall is sometimes protected with heavy rock rip-rap or gabions.

9.3.2. Inspection and Coding Procedures

- Check the headslope and the transition into the natural bank for signs of instability, i.e. cracks, slumps, erosion, etc.
- Note possible cause of instability or scour/erosion such as channel misalignment, drift accumulation, inadequate opening, etc.
- Check the protection system for signs of physical deterioration and displacement.
- If protection is required, but none exists, also rate under scour/erosion at abutments (section 8.11 Scour / Erosion). Also, recommend a protection system under 'Maintenance Recommendations'.
- Note the type of the headslope protection on the BIM form.

9.3.3. Rating Guidelines

- If no protection exists, and none is required, rate 7 or more and indicate Type as Natural.
- If no protection exists but is required, rate 4 or less and indicate Type as None.
- If the protection system is insufficient and/or needs repair, rate 4 or less.

9.4. GUIDEBANKS / SPURS

Component	Last	Now	Explanation of Condition
Guidebank/Spurs			

9.4.1. Background

A guidebank is generally an extension of the bridge headslope, constructed of earth fill and protected from erosion by a revetment system. The protection at the toe usually consists of a flexible system that prevents undermining. The primary function of the guidebank is to align flows through the bridge opening and to protect the abutment. They are generally vulnerable to attack at the upstream end (see Figure 9.1).

Spurs are used to inhibit bank erosion along the outside of bends, and along the toe of road embankments that are located in flood plains. They are also designed to avoid re-direction of the flow to bridge substructures or stable banks. They are generally constructed of either earth fill protected at the end with a revetment system or timber crib filled with timber logs (see Figure 9.2 and Figure 9.3).

Figure 9.1 - Guidebank with Concrete Slope Protection

Figure 9.2 - Rock Rip Rap Spurs

Figure 9.3 - Timber Crib Spurs

9.4.2. Inspection and Coding Procedures

- Check guidebank or earthfill spur for deterioration of the revetment system.
- Check toe of guidebank or earth fill spur (i.e. apron) for evidence of scour or loss of revetment material.
- Check timber spur for broken piles, missing limbed logs, missing nose plate, and loose or deteriorated connections. Also determine if spurs should be extended further into the bank or if additional spurs are required.
- Rate the physical condition of the guidebanks/spurs only. If this feature is ineffective, explain and recommend a solution in the 'Explanation of Condition' section.
- Rate the spurs as a group; that is, the condition of the worst spur should not dominate unless it reduces the effectiveness of the group.

9.4.3. Rating Guidelines

- If maintenance is required to improve its condition or functionality, rate 4 or less.
- If damage to the guidebank or spur will lead to further damage or loss with future floods, rate 3.

9.5. ADEQUACY OF OPENING

Component	Last	Now	Explanation of Condition
Adequacy of Opening			

9.5.1. Background

Adequacy of opening refers to the ability of the opening to pass the design discharge and associated debris without damaging the bridge or causing intolerable backwater. The size of the opening is defined by the boundaries of the streambed, the headslopes or abutments, and the bottom of the superstructure. The efficiency of the opening is dependent on its size as well as the hydraulic characteristics of the stream, debris accumulation, ice build-up, channel migration, aggradation, growth of willows, river control works, etc.

9.5.2. Inspection and Coding Procedures

- Check for reduction of the opening size. Look for evidence of debris accumulation, aggradation, and channel migration.
- Check upstream for high water marks, and height of ice scars.
- Look for unusual scour for the full width under the bridge.
- Check superstructure for evidence of impact due to floating debris or ice. Also look for high water marks.
- Look for river engineering works, especially on the downstream side.
- Rate the bridge opening only and not the approaches, even if they are submerged during flood.

9.5.3. Rating Guidelines

- An adequate opening, rate 5 or more.
- If there is a high-water mark indicating the water level was above the bottom of the girders, rate 4 or less.
- If there is a significant blockage of the bridge opening by a drift accumulation and/or beaver dams, rate 4 or less.

9.6. FISH COMPENSATION MEASURES

Component	Last	Now	Explanation of Condition
(Fish Compensation Measures 1 :)			
(Fish Compensation Measure 2 :)			

This is a section for the inspector to record any fish compensation measures at the site. A list of common or typical fish compensation measures is shown below:

Woody Plantings

Shrubs or small trees, often willows, planted in the riprap or adjacent to the streambed.

Root Wads

Tree trunks with the attached root mass; buried in the streambank perpendicular to the stream so that only the root mass protrudes from the bank.

Pike Marshes

Shallow off-channel marshes adjacent to a stream, with both shallow water zones up to 1.0 m deep and deep water zones 1.5 m to 2.0 m deep and planted with aquatic vegetation.

Instream Boulders

Boulders placed individually or in clusters in the streambed so that scour holes will be created along the sides and downstream or boulders placed in pre-excavated holes.

Instream Trees

Large weighted trees with attached roots and branches, sunk into a deep pool or run.

Rock Weirs

Small rock dams lower in the centre than at the sides to direct the flow towards the centre of the channel, often constructed as a V pointing upstream and sometimes used with a fish pool immediately downstream.

Fish Pools

Pools excavated in the bottom of a stream, 0.5 m to 2.0 m deep, sometimes lined with rock or with larger rocks placed in the bottom.

Fish compensation measures are not rated but the inspector is to provide comments as required.

9.7. General Rating

The channel general rating is governed by:

- channel alignment rating
- bank stability rating of 4 or less
- slope protection rating
- adequacy of opening rating

10. CHAPTER 10 - GRADE SEPARATION - BRIDGES

10.1. INTRODUCTION

This chapter applies to bridges which have the following structure usage classifications: GS - vehicular grade separation, PS - pedestrian grade separation, RO - railway overpass (road over railway), RU - railway underpass (road under railway). The BIM reports for this group of bridges are printed with items pertinent to the roadway/railway under the bridges as well as some selected bridge items, instead of the inspection items associated with the channel.

The grade separation section for culverts is covered in chapter 13, section 13.8.

In addition to the inspection items noted below, look for evidence of collision damage to piers, abutments, and girders. Also, the vertical clearance and associated posting information should be inspected as outlined in section 5.1.

10.2. ROAD ALIGNMENT

Component	Last	Now	Explanation of Condition
Grade Separation			
Road Alignment			

10.2.1. Background

This element refers to the road alignment beneath the bridge. It includes the horizontal and vertical alignments within a distance of 1 km measured from each side of the bridge. It should also consider the surface roughness in the vicinity of the crossing.

The rating should be done relative to acceptable condition and functionality similar to the rating of most other bridge elements.

10.2.2. Inspection and Coding Procedures

- Note the approximate degree of super elevation and its orientation below the bridge.
- Look for cracks, heaves, and uneven surfaces in the vicinity of the bridge that may cause unusual vertical movement of high load vehicles.

10.2.3. Rating Guidelines

- All railway alignments should be rated X.
- Alignments that can be safely driven at the legal or posted speed, rate 5 or more.

10.3. TRAFFIC SAFETY FEATURES

Component		Last	Now	Explanation of Condition
Traffic Safety Features				
Type				

10.3.1. Background

For the purpose of this section, traffic safety features refer to curbs, medians, guardrails, energy attenuators, and advance warning signs.

Curbs, medians and guardrails are sometimes used in combination to minimize collision with bridge piers, abutments, and headslopes. Energy attenuators, such as the steel drum systems, are commonly used in front of bridge piers.

10.3.2. Inspection and Coding Procedures

- Record the types of safety features that are present on site.
- Check the connections for guardrails, energy attenuators, vertical clearance signs, etc.
- Check the connections of all the safety features found on site.
- The rating should reflect the overall condition of the safety features and their attachments.

10.3.3. Rating Guidelines

- If one or more safety feature is substandard or missing, rate 4 or less.
- If a safety feature is missing, in poor condition or not functioning and results in a hazardous situation, rate 2 or less.

10.4. SLOPE PROTECTION

Component	Last	Now	Explanation of Condition
Slope Protection			
(Type :)			

10.4.1. Background

This item refers to the protection system used on the headslope to prevent erosion or gullying as well as providing a good appearance. Most of the problems with slope protection are caused by inadequate compaction of the fill during construction or drainage from the road and bridge.

10.4.2. Inspection and Coding Procedures

- Look in the vicinity of the abutment for evidence of settlement of the headslope fill.
- On concrete slope protection, check for concrete deterioration and cracks. Also look for gaps between the abutment and the slab, crushing of concrete around

the piers, and bulging at the toe. Check cutoffs or retaining walls at the toe for tilting. These generally indicate down slope movement of the slab.

- Also for concrete slope protection, check in the areas of the drain troughs and piers to determine if water is penetrating below the slab.
- For other types of protection systems such as rocks, gravel, and concrete sacks, check for loss, disintegration, or displacement of the protection material.
- Note if graffiti exists on the slope protection.
- Hammer sounding may be used to determine the presence of voids under the concrete slope protection.

10.4.3. Rating Guidelines

- If the slope protection is settling significantly or moving downwards, rate 4 or less.
- If there is significant heaving or cracking of concrete slope protection, rate 4 or less.
- If there are voids under the concrete slope protection, rate 4 or less.

10.5. BANK STABILITY

Component	Last	Now	Explanation of Condition
Bank Stability			

10.5.1. Background

Bank stability refers to the stability of the headslope and its transitions. The stability generally depends on several factors such as backfill material, construction techniques, compaction, and the drainage systems. The consequences of an unstable slope depend on the extent of the failure and may range from minor settlement of the fill to instability of the entire structure.

10.5.2. Inspection and Coding Procedures

- Look for evidence of damage and/or displacement in the slope protection systems.
- Look for evidence of settlement around the abutments and piers.
- Check toe of the slope for bulging or loss of material due to piping, etc.
- Record locations of slumps and wet areas.

10.5.3. Rating Guidelines

- If the slope has settled to the point of exposing the underside of the abutment seat, rate 4 or less.
- Instability that affects the substructure or superstructure, rate 4 or less.
- Instability that requires monitoring, rate 4 or less.

10.6. DRAINAGE

Component	Last	Now	Explanation of Condition
Drainage			

10.6.1. Background

For the purpose of this section, drainage refers to the disposal of water that reaches the toe of the headslope and its transition. Typical sources of water are from the bridge deck, approach roads, highway ditch, and weep holes in abutments and concrete slabs. The condition and effectiveness of drain troughs and catch basins are rated in section 6.7 Drainage. Deck drainage is also rated in section 7.8 Deck Drainage.

10.6.2. Inspection and Coding Procedures

- Look for signs of ponding around the headslopes and its transitions.
- Determine if existing gutters or other water disposal systems are clogged or functioning.

10.6.3. Rating Guidelines

- If the drainage system is functioning and does not contribute to damage of the slope protection or bank instability, rate 5 or more.
- If drainage contributes to slope protection damage or slope instability, rate 4 or less.
- If drainage causes ponding or icing on travel lanes creating hazardous situation, rate 2 or less.

10.7. GENERAL RATING

The grade separation general rating is governed by:

- road alignment rating
- traffic safety features rating
- bank stability rating
- drainage rating

11. CHAPTER 11 - BRIDGE INSPECTION / MAINTENANCE SUMMARY

11.1. INTRODUCTION

This chapter deals with the items noted on the last page of every BIM report. This page constitutes a summary of the structural condition of the bridge, its relative functional capabilities, routine maintenance requirements, and details of the high priority maintenance items. It provides most of the pertinent engineering information required to establish priorities for maintenance, rehabilitation and reconstruction. This page is shown on the inspection form in landscape but in this chapter, for illustration, the sections are shown in portrait.

A reliable bridge inspection program must be complimented with an effective maintenance operation to ensure identified structural deficiencies and problems are addressed properly. It is believed that the trained bridge inspector, knowledgeable in routine bridge maintenance works, is in the best position to make maintenance recommendations while at the site.

11.2. MAINTENANCE RECOMMENDATIONS

Maintenance Recommendations						
Inspector Recommendations	Year	Inspector Comments	Department Comments	Target Yr	Est. Cost	Cat#
REPAIR/REPLACE BRIDGERAIL						
GALVANIZE / PAINT RAIL						
RETROFIT BRIDGERAIL						
REPAIR/SEAL CURBS						
PATCH DECK						
SEAL DECK						
OVERLAY DECK						
REPAIR/REPLACE DECK JOINT						
REPLACE STRIP DECK						
RELACE SUB DECK						
RESET/PAINT BEARINGS						
REPAINT SUPERSTRUCTURE						
STRAIGHTEN/REPLACE MEMBERS						
ULTRASONIC INSPECTION						
WASHING						
SHOTCRETE REPAIRS						
CORE TIMBER CAPS/CORBELS						
REPLACE TIMBER CAPS/CORBELS						
REPAIR ABUTMENT SCOUR/EROSION						
PLACE ADDITIONAL RIP RAP						
REMOVE DRIFT ACCUMULATION						
OTHER ACTION						
OTHER ACTION						
OTHER ACTION						
Structural Condition Rating (Last/Now) (%)		Sufficiency Rating (Last/Now) (%)	Est. Repl. Yr		Maint. Reqd. (Y/N)	

11.2.1. Background

This section contains a list of typical maintenance recommendations for bridges and space for additional items. The inspector fills in the year that the maintenance should be completed together with comments and estimated quantities (separate sheet, if required). After the inspection report is submitted, the Department reviewer provides comments, target year and cost estimate if in agreement with recommendations, and assigns a category number to assist in programming the maintenance actions.

11.2.2. Guidelines for Maintenance Recommendations

- Bridge elements rated 5 or more should not have any maintenance recommendations except for preventative maintenance items such as washing, silane sealing, etc.
- Bridge elements rated 3 or less should have a maintenance recommendation with an accompanying photograph.

- Maintenance recommendations can include any of the following: replacement, repair, rehabilitation, assessment, Level 2 inspections, reduced inspection cycle or monitoring.
- The recommendation to “monitor” should be used sparingly. It should be used for items that are measurable and where comparison of changes can be made with clear and readily identifiable reference marks.
- Timing of bridge maintenance recommendation should generally follow the time-lines indicated below depending on the element rating and also take into consideration the routine inspection cycle for the bridge:
  - 4 low priority
  - 3 (structural element) medium priority, repairs and maintenance completed before the next inspection (six months to three years) e.g. timber cap rated 3, fix within a year
  - 3 (non-structural) repairs may be delayed if defect not impacting life and operation of the structure e.g. bridgerail coating rated 3
  - 2 high priority, repairs and maintenance completed within six months
  - 1 immediate action
- If there are no maintenance recommendations the inspector records N in the ‘Maintenance Required’ field. If there are maintenance recommendations, record Y.

11.2.3. Estimating Quantities

Where practical and applicable, the inspector is to estimate the material quantities required for recommended repairs and maintenance. These estimated quantities are to be recorded on a separate sheet of paper and submitted with the inspection report.

Example:

- 5 – 305mm x 75mm x 3.0m long timber stripdeck planks

11.2.4. Recommending Level 2 Inspections

Level 2 inspections are detailed inspections requiring specialized equipment and/or expertise. These inspections gather specific information, measurements and observations not captured on the routine Level 1 inspections. Further information on Level 2 inspections may be found in the Level 2 BIM Inspection Manual. Recommendations for Level 2 inspections can be made by inspectors during the routine Level 1 inspection. The Department will review the recommendations and make arrangements for the Level 2 inspection if it is required.

Municipalities should not undertake any site preparation measures until the Bridge Manager has been contacted and agrees a Level 2 inspection is required.

11.2.5. Recommending Additional Inspections after 2 Consecutive N Ratings

If a structural load carrying element has a rating of N for two consecutive inspections and the element may govern the Substructure or Superstructure General rating, an additional inspection of the element should be recommended. This inspection could be either a Level 1 inspection in a different season or a Level 2 inspection with the necessary equipment mobilized to access the element in question.

The decision to proceed with an additional inspection will be made by the Bridge Manager or his designate based upon the element in question, age and condition of the structure and other factors. No planning or preparation for an additional inspection should be done until the Bridge Manager has reviewed the recommendation and is in agreement with it.

11.2.6. Timber Coring

Level 2 timber coring inspections are recommended when there are suspicions of rot in timber elements. Particular attention should be given to the critical structural load carrying elements such as timber caps, piles and stringers. Coring is generally conducted on timber load carrying substructure elements where rot is suspected or the element is 25 years or older. Subsequent coring may be required based on the results of the initial coring.

11.3. ESTIMATED REPLACEMENT YEAR

The estimated replacement year is the inspector's subjective estimate, at the time of the inspection, of when the structure will need to be replaced assuming normal/routine maintenance is carried out but without including the effects of possible major rehabilitation. This estimate should be based on factors such as structural condition, horizontal and vertical alignments, traffic volumes, age, etc.

Life expectancy tables for each standard bridge type are provided below to help with this estimation.

The values in the table are averages only and the inspector must apply judgment based on the actual condition of the structure. The table is separated into three categories for low, average and high life expectancy.

LIFE EXPECTANCY TABLE FOR STANDARD BRIDGES			
TYPE	LIFE EXPECTANCY (YEARS)		
	Low	Average	High
Untreated Timber (UT)	10	15	20
Treated Timber (TT)	35	40	45
Prestressed – Composite (SCC,SMC,SCM,SLC)	55	60	70
Prestressed (SC, SM, VS)**	40	45	60*
Precast (HC, VH, HH, PG, GR, MM, PES)**	30	35	50
Precast (PA) & Other (PX)	25	30	45
* Use maximum of 50 years for timber substructure ** Add five years if overlaid with concrete			

Considerations:

- traffic characteristics – volume, amount of truck traffic, log haul
- salt usage – road surfacing, traffic, climatic conditions
- deck drainage, leakage
- favourable decay conditions

Table 11.1 - Life Expectancy Table for Standard Bridges

LIFE EXPECTANCY TABLE FOR MAJOR BRIDGES			
TYPE	LIFE EXPECTANCY (YEARS)		
	Low	Average	High
CONCRETE:			
Prestressed Girder (CBC, DBC, CBT, DBT, FM, LF, NU, OM, PB, PO, PQ, RD, RM, FC, PM, VF, VM)**	45	55*	70*
Precast Girder (GR, MM, PE, PES, PS)**	30	35	50
Cast-in place (CA, CF,CB, CS,CT, CV, CX)**	40	50	60
* Use maximum of 50 years for timber substructure ** Add five years if overlaid with concrete ** Add five years if strengthened or laterally stressed			
STEEL:			
Rigid Frame (FR) & Welded Girder (WG) & Deck Truss (DT)	60	70	80
Rolled Beams (RB)	50	60*	80*
Riveted Plate Girder (RG)	40	50	70*
Through Truss (TH) & Pony Truss (PT)	40	50	70*
Bailey (BSS) & Other Types (SS)	30	40	50
* Use maximum of 50 years for timber substructure			

Considerations:

- traffic characteristics – volume, amount of truck traffic, log haul
- salt usage – road surfacing, traffic, climatic conditions
- deck drainage, leakage
- favorable decay conditions
- design or rated load capacity

Table 11.2 - Life Expectancy Table for Major Bridges

As stated earlier, the estimated replacement year assumes that all required routine maintenance is carried out. Routine maintenance is maintenance and repair actions that do not have enough impact on the structure to extend the life of the structure, e.g. patch deck, repair curbs, replace asphalt, replace strip deck, replace timber caps, repair bearings. The line between maintenance that would or would not extend the life of a structure is not always clear and the inspector has to use a great deal of judgment in these cases. For example, the replacement of a timber cap with another timber cap probably does not extend the overall life of the structure and should be considered routine maintenance. However, replacement of all timber caps with steel caps might extend the life of the structure and would be considered major rehabilitation.

11.4. SPECIAL COMMENTS FOR NEXT INSPECTION

Special Comments for Next Inspection		Department Comments	

The bridge inspector may use this space to record comments that would be useful for the next inspection. If monitoring is recommended this is the place to record measurements and/or note reference points for next inspection. Do not list maintenance items in this space since this field does not permit sorting of data.

The ‘Department Comment’ field allows the Department reviewer to make notes, comments or recommendations.

11.5. MAINTENANCE/REHABILITATION STRATEGY

Maintenance Reviewed by		Date		Estimated Total	
Proposed Long-Term Strategy					
On 3-Year Program (Y/N)					
Proposed Action					
Previous Inspector’s Name		Previous Assistant’s Name			
		Previous Inspection Date			

11.5.1. Background

This section of the form is filled out by the Department reviewer.

11.5.2. Maintenance reviewed by

The inspection form and the maintenance recommendations are reviewed by a Department staff reviewer. If required, the reviewer will provide a target year for specific maintenance recommendations together with an estimated cost and priority category. After review, the Department reviewer records name, date of the review and the estimated cost of all accepted maintenance recommendations.

11.5.3. Proposed Long-Term Strategy

An assessment may have already been carried out on a bridge structure and a long-term strategy may have been proposed. If this is the case, the Department reviewer records this information in the space provided or in the future this may be automatically generated from a Department assessment data base.

Proposed work on this structure may already be on the Department’s 3-year program. If this is the case the Department reviewer records Y and lists the proposed action. This information may also be automatically generated in the future from the Department's programming process.

11.5.4. Previous Inspector's Name and Date

The previous inspector's name and the name of the assistant inspector (if applicable) along with the date of the previous inspection is automatically generated from the BIM system and printed out on the next inspection form.

11.6. NEXT INSPECTION DATE/INSPECTION CYCLE

Next Inspection Date		
Inspection Cycle (months)		
Comment		

The next inspection date is system generated based on the last inspection date and the appropriate inspection cycle or is manually changed by the Department reviewer. The cycle may be the normal default cycle for the type of bridge and class of roadway (see section 2.5) or may be modified by the Department reviewer as noted in the 'Comment' field. If the inspector feels that a shorter inspection cycle than the default cycle is required, the shorter inspection cycle should be noted in the 'Special Comments for Next Inspection' field together with comments justifying the recommendations for a modified cycle. The inspector can only recommend a shorter cycle. The inspector cannot recommend a longer inspection cycle then the default cycle.

12. CHAPTER 12 - BRIDGE STRUCTURAL CONDITION AND SUFFICIENCY RATINGS

12.1. STRUCTURAL CONDITION RATING

The structural condition rating for the last routine inspection is calculated by the computer and printed in terms of a percentage. It is the ratio of the sum of the general ratings to the sum of the maximum possible ratings for the superstructure and substructure only. That is,

SCR = ((Gen. Rating Super + Gen. Rating Sub) /18) 100 %

It reflects the structural condition of the bridge at the time of the last inspection compared to the structural condition of a new bridge without any defects. For bridges with secondary spans, the lowest of the superstructure general ratings is used.

12.2. SUFFICIENCY RATING

12.2.1. Background

The bridge sufficiency rating is a computerized procedure that is undertaken automatically by the BIM system module to produce a single numerical value in terms of a percentage using four major impact categories to represent the present condition, level of service, safety of a bridge and its approach roads, relative to the acceptable standard of a new bridge at the same location. This rating is calculated by applying a set of mathematical formulas to the inspection and inventory data after each inspection, and is printed on the last page of the BIM form. The rating ranges from 0% to 100%, with the lower rating indicative of a higher priority for replacement, rehabilitation, or maintenance. A numerical value of 100% is representative of a bridge that is in excellent condition and provides the best possible level of service at its present location; whereas a value of 50% is likely representative of a bridge that provides a safe and/or acceptable level of service that meets the minimum desirable standard.

12.2.2. Sufficiency Rating Uses

The bridge sufficiency rating is intended to be used with other related criteria to:

1. Provide a rational basis for facilitating bridge management functions which include priority planning for replacement, rehabilitation, and maintenance.
2. Evaluate the adequacy of bridges in their present condition to adequately serve public needs on a regional or provincial basis.
3. Provide data that can be used to evaluate the cost of replacement or rehabilitation in order to achieve an acceptable level of service.

It should be recognized that the sufficiency rating should not be used as the only basis for management decisions since it does not include any cost/benefit factor, economic factor, social, or environmental factor; nor does it identify alternatives, optimal solutions, timing, or budgetary constraints, etc.

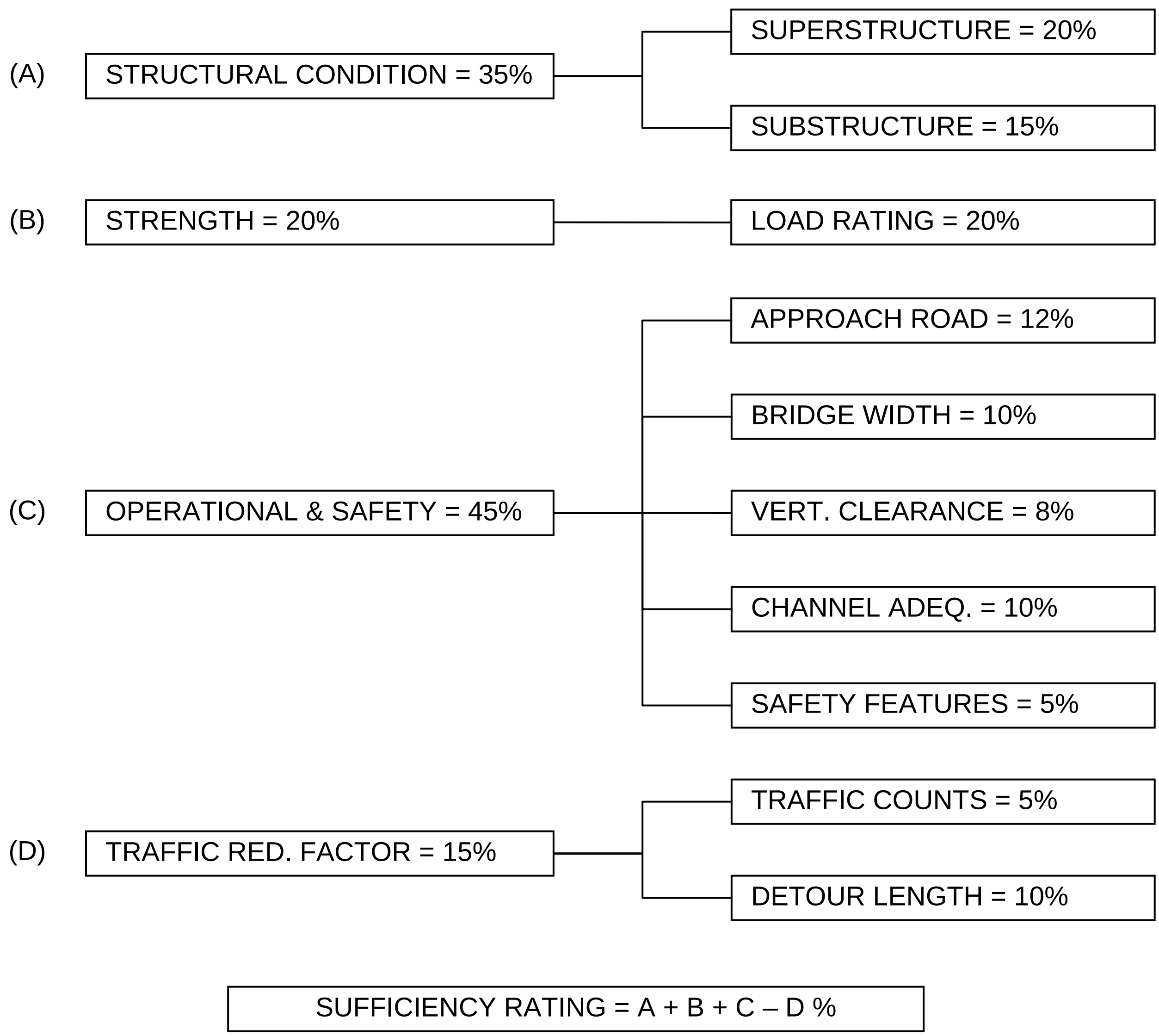


Figure 12.1 - Sufficiency Rating Components

12.2.3. Sufficiency Rating Components

The general outline of the sufficiency rating is shown on Figure 12.1. It uses data from the BIM system and other TIMS system modules. Once the inspection data is entered into the computer, the sufficiency rating is calculated automatically using a series of pre-determined formulas. Thus, the sufficiency rating is a by-product resulting from the use of existing inspection and inventory data.

The rating considers four major impact categories which are weighted in accordance with their relative importance. These are structural condition (35%), strength (20%), service and safety (45%). In addition, a traffic reduction factor (15%) is included as an adjustment to reflect the influence of traffic volumes and detour lengths. Each impact category is further divided into elements which are also weighted to indicate their relative importance. These elements are either subjective (57%), or objective (58% including the traffic reduction factor). The elements which require subjective judgment include up to 22 separate inspection items.

The distribution of the total allocated points for each element is calculated as shown below.

12.2.3.1. (A) Structural Condition

This category consists of two elements: superstructure (20%) and substructure (15%). The distribution of the allocated points is directly related to the general condition rating (GR) for each element. The general rating must be noted on the BIM forms. The lower of the two general ratings for superstructure is used for bridges with secondary spans.

For Superstructure: A1 = 2.5 x (GR – 1) %

For Substructure: A2 = 1.875 x (GR – 1) %

12.2.3.2. (B) Strength:

The strength category is related to the inventory loading of the bridge. The inventory loading is calculated by another system module and printed on the BIM form in terms of the CS1, CS2 and CS3 truck configurations. Where this information is not available, the program uses the Design Loading instead. A default value of HS 15 is used for bridges with no inventory or design loading. This calculation is done for both the primary and secondary (if present) spans, and the program selects the lower of the two values.

For Inventory Loading: B1A = 0.333 x (CS3 Rating - 30) %

Typical Example:

CS3 Truck (Gross tonnes)	Points
90 or better	20
75	15
60	10
45	5
30	0

Note: Use 1.25 x HS Rating if CS3 Rating is not available. CS3 Rating and HS Rating are in gross tonnes.

For Design Loading: B1B = 0.333 x (3.6 HS truck - 30) %

Typical Example:

Design Load	Points
CL 800	20
CS 750	20
HS 25 or better	20
HS 20	14
HS 15	8

12.2.3.3. (C) Operational & Safety:

This category consists of five elements: approach road (12%), bridge width (10%), vertical clearance (8%), channel adequacy (10%), and traffic safety features (5%).

Approach Roads:

The sufficiency rating of the bridge approaches is related to the general rating which must be noted on the BIM form by the bridge inspector after considering:

a) the existing vertical and horizontal alignments
b) approach bump at the ends of the bridge as an indication of embankment stability, etc.
c) other related factors such as approach road drainage

For Approach Roads: C1 = 1.5 x (GR – 1) %

Note: GR = 9 when the approach road rating is greater or equal to 5.

Bridge Width:

The sufficiency rating for bridge width is determined by comparing the bridge width to the width of the approach roads or the designated roadway width (road classification), whichever is larger. If the bridge width is not available in BIS, the program uses a default value of 7.6 m. Similarly, the default values for roadway width are: 8.0 m for Local Roads and 9.0 m or 11.0 m for Provincial Highways.

The rating for bridge width is the lesser value of either C2A or C2B, obtained by the following formulas:

For Bridge Width: C2A = 28.571 x ((BW/RW) - 0.65) %

OR

For Bridge Width: C2B = 4.0 x (BW - 4.8) %

Where, BW is the clear roadway of the bridge in metres. RW is the larger of the approach roadway width or the road classification roadway width. C2B = 10 if BW is equal to or greater than 7.3 metres.

Vertical Clearance:

Bridges without vertical clearance restrictions, or those with vertical clearances of 5.3 or more, are given the full allotment of eight points. Bridges with vertical clearances that are below the legal limit of 4.15 m are given zero points. For bridges with more than one vertical clearance posting, the program uses the lower value.

For Vertical Clearance: $C3 = 6.956 \times (VC - 4.15)\ \%$

Where, VC is the measured minimum vertical clearance if available or else the minimum theoretical value from BIS. For overpasses and Through Trusses without vertical clearance records, a default value of 4.7 m is used.

Channel:

Channel adequacy is defined as the capability of the Channel Section under the bridge to pass the design discharge without causing flooding of the bridge approaches and/or areas upstream of the bridge.

The sufficiency rating depends on the general rating of the channel noted on the BIM form. The general rating considers channel adequacy as well as channel alignment, bank stability, drift, and slope protection. For grade separations or pedestrian overpasses the program uses the general rating for the grade separation section of the BIM reports. The general rating must be provided on the BIM reports.

For Channel Adequacy: $C4 = 1.25 \times (GR - 1)\ \%$

Traffic Safety:

The traffic safety features include posting information, approach guardrails, wearing surface, and bridgerails. The sufficiency rating is calculated automatically based on information noted on the BIM form. The total allotment of five points is assigned as follows:

Posting Information:

If all the required signs regarding:

a) vertical clearance for grade separations and through trusses
b) load limits for bridges that should be posted
c) hazard markers where required

are in place then the bridge is credited with 1 point. Bridges with one or more missing signs are given zero points.

Approach Guardrails:

If the approach guardrails on all four corners of the bridge meet the current standard, the bridge is credited with 1 point.

Deck Rideability:

If the rating of Deck Rideability is rated 5 or more, the bridge will be credited with 1 point.

Bridgerail:

If the bridgerail type noted on the BIM form is tube type, flexbeam, retrofit, steel tube, then the bridge is credited with 1 point. Also, if the bridgerail type is as noted above and if the condition rating of the bridgerail is 5 or more, then the bridge is given an additional point.

12.2.3.4. (D) Traffic Reduction Factor:

This category consists of AADT (5%) and Detour Length (10%). This reduction factor is applied to the sum of categories A, B, and C in a manner that reflects the impact on the rate of deterioration, public convenience due to traffic volumes, and the length of detour. In other words, priority for rehabilitation or replacement will be given to the bridge with the highest traffic volumes and/or longer detour compared to bridges with the same total points in categories A, B, and C.

AADT:

For Provincial Highways, the AADT is automatically placed on the BIM form.

The default values used when the AADT is not available are:

Local Roads = 70 vpd
Provincial Highways (1-216, 900+) = 300 vpd per lane
Provincial Highways (500-899) = 150 vpd

The reduction factor for AADT is the lesser value of either D1A or D1B, obtained by the following formulas:

For AADT: D1A = (((AADT - 25) / 36) exp. 0.28) - 0.5 %

Where, D1A = 0 for AADT equal to or less than 25.
D1A = 5 for AADT equal to or greater than 15000.
AADT is for 2-lane bridges only. For 4-lane and 6-lane bridges, the AADT is divided by 2 and 3 respectively.

OR

For AADT: D1B = 0.10 x (100 - (A+B+C))%

Where, D1B = 0 when (A+B+C) is equal to 100.
D1B = 5 when (A+B+C) is equal to or less than 50.

Example: If the AADT = 4000, and (A+B+C) = 80
Then D1A = 3.23, and D1B = 2.0 (governs)
Therefore, the reduction factor for AADT = 2.0

Detour Length:

The detour length is defined as the extra distance to be traveled if the bridge on the intended route is removed. In general, the detour bridge is the nearest bridge on the same stream that has about the same load capacity, or one that can be temporarily strengthened on short notice. This factor places a higher priority for replacing a bridge with a longer detour and higher traffic volume than the same bridge with either a shorter detour and/or lower traffic volume.

The default values used when the detour length is not available are:

Local Roads = 75 km
Provincial Highways = 40 km or 8 km for two lanes, and reduced by 1 km for each extra lane.

The reduction factor for Detour Length is the lesser value of either D2A or D2B, obtained by the following formulas:

For Detour: D2A = (AADT) x (Detour Length) / 3000 %

Detour Length is in kilometres.

OR

For Detour: D2B = 0.20 x (100 - (A+B+C)) %

Where, D2B = 0 when (A+B+C) is equal to 100.
D2B = 10 when (A+B+C) is equal to or less than 50.

Example: If the AADT = 1500, the Detour Length is 13 km, and (A+B+C) = 55
Then D2A = 6.5 (governs), and D2B = 9.0
Therefore, the reduction factor for Detour Length is 6.5

12.2.4. Sample Calculation - Sufficiency Rating

The following information was extracted manually from a BIM report:

Superstructure general rating = 6
Substructure general rating = 5
Approach roads general rating = 4
Channel general rating = 6
Bridge width = 7.6 m
Road classification is RLU 208G-090
Roadway width = 9.0 m
No inventory loading available: Design Loading is HS 20
No vertical clearance restrictions
One hazard sign missing
Approach guardrails do not meet standards
Bridge has timber rails with a condition rating = 6
Deck rideability rating = 8
AADT = 100
Detour Length = 8 km

Step 1	**Structural Condition (A):**	
	For Superstructure:	A1 = 2.5 x (6 - 1) = 12.5%
	For Substructure:	A2 = 1.875 x (5 - 1) = 7.5% Thus, A = 12.5 + 7.5 = 20%
Step 2	**Loading (B):**	
	For Design Loading:	B1B = 0.333 x ((3.6 x 14) - 30) = 6.8%
Step 3	**Operational & Safety (C):**	
	For Approach Roads:	C1 = 1.5 x (4 - 1) = 4.5%
	For Bridge Width:	C2A = 28.571 x ((7.6 / 9) - 0.65) = 5.6% (governs) C2B = 10% since BW is greater than 7.3 m
	For Vertical Clearance:	C3 = 8%
	For Channel Adequacy:	C4 = 1.25 x (6 - 1) = 6.3%
	For Traffic Safety Features:	Posting Info = 0 (missing sign) Approach Guardrails = 0 (do not meet std.) Bridgerails = 0 for timber rails Deck Rideability = 1 Thus, C = 4.5 + 5.6 + 8 + 6.3 + 1= 25.4%
Step 4	**Traffic Reduction Factor (D):**	
	For AADT:	D1A = (((100 - 25)/ 36) exp. 0.28) - 0.5 = 0.7% D1B = 0.10 x (100 - (20+6.8+ 25.4)) = 4.8%
	For Detour Length:	D2A = (100 x 8) / 3000= 0.3% D2B = 0.2 (100 - (20+6.8+25.4)) = 9.6% Thus, D = 0.7 + 0.3 = 1%

SUFFICIENCY RATING IS = (20 +6.8 +25.4 - 1) = 51.2 %

13. CHAPTER 13 - CULVERTS

13.1. INTRODUCTION

The use of culverts has increased significantly over the years since they provide an efficient and economical alternative to conventional bridges. These advantages have encouraged changes in design methods that lead to thinner walls, use of new and innovative material combinations and shapes, and the development of larger span culverts.

For the purpose of this manual, culverts are defined as structures that are completely surrounded by soil, and located below the surface of the roadway parallel to the general direction of the stream flow. All bridge-size culverts, defined as having an equivalent flow area of 1500 mm or more, are inspected on the same routine inspection intervals specified for bridges. Culverts with equivalent flow area less than 1500 mm are also inspected routinely if they are part of a low level crossing.

Approximately 52% of all stream and canal crossings in the Province consist of culverts. Of these, less than 1% are timber, less than 5% are concrete, and more than 94% are metal culverts. The contents and layout of the BIM inspection form are the same for all types of culverts.

There are three types of BIM culvert reports:

- CUL1 for single pipe culvert structures or culverts extended with same size of pipe
- CULE for single culverts extended with different size and/or type of material
- CULM for multiple pipe culvert structures

The description of the three types of culvert reports and when they are used is given below:

CUL1

This report is used for sites with a single culvert pipe. This form will also be used for a single pipe that has been extended with a pipe of the same size and material. The form consists of one upstream section, one barrel section and one downstream section. The original barrel and possible extended barrel are inspected together with the worst condition state governing.

CULE

This report is used for a single pipe which has been extended with different material and/or size of pipe. The form consists of one upstream section, two barrel sections and one downstream section. The original barrel and the extended barrel are inspected separately.

CULM

This report is used when there are multiple pipes or cells at the culvert site. For sites where there are multiple pipes, the form consists of an upstream section, barrel section and downstream section for each pipe. For concrete box culverts with multiple cells, the form consists of one upstream section, one barrel section for each cell and one down stream section. For a multiple cell concrete box extended with single barrel steel pipe, the form has one upstream section, one barrel section for each concrete cell, one barrel section for the extended steel pipe and one downstream section.

Timber and concrete culverts are classified as "rigid culverts" and are designed to carry external loads without deflection. Inspection of rigid culverts is similar to the inspection of bridge components in that the actual load bearing components are examined directly. All timber components must be checked for decay, cracks, movement, gaps, and loose connections. Concrete components must be checked for cracks and deterioration that may be caused by poor concrete or an acidic environment.

Metal culverts are classified as "flexible culverts". They have low bending strength and are dependent on the surrounding backfill for load carrying capacity. Figure 13.1 and Figure 13.2 show pictures of assembly and backfill of flexible metal culverts. Although the metal culvert can be inspected from the inside, the backfill cannot be inspected directly. Thus, the inspector must be able to observe symptoms in the metal pipe in order to diagnose problems with the backfill. This type of culvert is more susceptible to failure caused by:

a) change in design shape due to excessive deflection
b) defective joints which may show up as cracks in the bolt holes, misalignment of plates or sections, open joints, and cusped or crimpled seams
c) corrosion of the plates and bolts from the soil and water sides of the barrel
d) uplift of the ends due to buoyancy forces resulting from a significant difference in water level between the outside and inside of the culvert

The rating system and recording procedures for culverts are the same as those for bridges. Also, the inventory and general information noted at the top of page one of the BIM report is similar to bridges (see Chapter 4 for details).

Culverts are often used for cattlepasses. In some cases the cattlepass may also be used to carry water flow. It may not be apparent to the inspector if a particular cattlepass has been designed for the dual purpose of a cattlepass and to carry water flow. When these dual purpose cattlepasses are identified, a comment should be added in the 'Special Comments For Next Inspection' along with the inspector's name and date.

For example:

Special Comments for Next Inspection	This culvert also handles drainage. John Doe, August 25, 2005	Department Comments	

If a cattlepass is noted as serving this dual purpose, the inspector is to rate scour, scour protection, fish passage and waterway adequacy. Otherwise, these elements are to be rated X.

Figure 13.1 - Assembly of SPCSP Culvert

Figure 13.2 - Backfill of SPCSP Culvert

13.2. CULVERT INFORMATION

Bridge Culvert Inspection								
Bridge Culvert Information								
Number of Culverts								
Pipe #	Barrel	Span	Rise (or Dia.)	Type	Length	Corr. Profile	Pl Thickness	Shape
1								
1								
2								
2								
Special Features								
Special Features Comment								

13.2.1. Number of Culverts

This information is extracted from BIS and indicates the number of culverts that are at the site.

13.2.2. Span / Rise (Or Dia.)

This information is extracted from BIS and indicates the span and rise to the nearest millimeter. For round culverts, the Rise (or Dia.) field is filled in and the span field is left blank. The rise and span information shown is intended to reflect the original design shape.

13.2.3. Span Type

This information is extracted from BIS, and indicates the material type as well as the shape of the structure. For a specific list of culvert span types see BIS documentation. Common span types for bridge culverts are:

Corrugated Metal Pipe (CSP/CMP)

This is a culvert manufactured in complete sections (rings) from corrugated metal material. The metal is normally steel but aluminum can also be used. They are normally round but can be manufactured in arch shapes.

Structural Plate Corrugated Metal Pipe (SPCSP/SPCMP)

This is a culvert constructed from segments of corrugated metal structural plate bent to various radii. The plates are bolted together along longitudinal and circumferential seams. Since the plates can be different radii, the culvert can be round, arch or elliptical in shape. Also, these culverts do not have to be complete rings and can have open bottoms with the culvert walls supported by concrete footings.

Cast-in-Place Concrete (CIP)

This is a culvert constructed of cast-in-place reinforced concrete. The shape can be single or multi-cell box or concrete arch.

Precast Concrete Pipe

This is a culvert constructed using precast concrete sections. They can be round, box or arch shapes.

Smooth Steel Pipe

This is a culvert constructed with a smooth wall steel pipe.

13.2.4. Length

The length is shown to the nearest 0.1 meter and reflects the invert length of the culvert. This information is extracted from BIS. For sites with multiple culverts, the inspector should also note the invert lengths of the secondary culverts on the BIM form.

13.2.5. Corrugation Profile

This information is extracted from BIS. It only applies to flexible culverts (i.e. CSP, CMP, SPCSP or SPCMP). Table 13.1 shows corrugation profiles for CSP and SPCSP.

	Corrugated Steel Pipe (CSP/CMP)	Structural Plate Corrugated Steel Pipe (SPCSP/SPCMP)
Corrugation Profiles (pitch x depth)	38 X 6.5 mm	152 x 51 mm
	68 x 13 mm	380 x 140 mm
	76 x 25 mm	400 x 150 mm
	125 x 26 mm	

Table 13.1 - Corrugation Profile

13.2.6. Plate Thickness

This information is extracted from BIS, and only applies to flexible culverts. Corrugated Steel Pipes (CSP) are manufactured with up to seven nominal thicknesses, depending on the corrugation profile. Structural Plate Corrugated Steel Pipes (SPCSP) are manufactured with five nominal plate thicknesses. Table 13.2 shows plate thicknesses for CSP and SPCSP.

Corrugated Steel Pipe (CSP)		Structural Plate Corrugated Steel Pipe (SPCSP)
Gauge	Nominal mm	Nominal mm
20	1.0	3
18	1.3	4
16	1.6	5
14	2.0	6
12	2.8	7
10	3.5	
8	4.3	

Table 13.2 - Plate Thickness for CSP and SPCSP

13.2.7. Special Features

This item is extracted from BIS and printed on the culvert form. It refers to unique design features that are used on the barrel section for extra strength and/or better soil-structure interaction. These special features include concrete thrust beams, unattached concrete slabs, concrete slab attached with shear connectors at the end sections of the barrel only, metal ribs, metal ribs and metal ears, and straw bales. The special features comment field can be used for comments, measurements, etc.

Special features do not refer to span types such as RPA (ABC & CAB). An Arch Beam Culvert (ABC) is a horizontal elliptical structural plate culvert with a composite concrete slab which extends over the sidewall backfill. A Culvert Arch Beam (CAB) is similar to the ABC except the CAB has a slotted angle iron joint along each spring line to allow for a small amount of differential movement between the composite roof slab and the bottom section of the culvert to avoid cracking of the seams at the spring line.

13.3. UTILITIES

Utilities (Located at)			
Telephone		Gas	
Power		Municipal	
Others		Problem (Y/N)	
Remarks			

13.3.1. Background

The owner of the utility is responsible for its inspection, maintenance, and operation. The bridge inspector is not required to provide a condition rating for each utility attached to the culvert or located within the right-of-way adjacent to the culvert. However, the bridge inspector must check all utilities, since they may interfere with routine maintenance, operation of the culvert or constitute a hazard to the traveling public.

The owner must apply for permission from the Bridge Manager before installing any utility on a culvert. Utilities are not normally permitted to be attached to the inside of a culvert.

13.3.2. Inspection and Coding Procedures

- Note the location of each utility. (i.e. 2 wire OH; S of CL).
- Look for excessive sagging that may cause cracks or leaks, and/or may reduce vertical clearance or freeboard.
- Look for signs of damage, corrosion, and loose connections on the utility and its supports.
- Check for evidence of leaks on water or sewer pipes. Leaks may cause hazardous conditions in culverts that are used as grade separations or stock underpasses.
- Note any utility that may interfere with routine maintenance.
- Municipal utilities may include water and sewer.

- Utilities with any problems which constitute a hazard to the public, the structure, or use of the structure should be recorded on the BIM form and reported as soon as possible to the Bridge Manager.
- Note the locations of all utilities, such as power poles, etc., found at the site.
- Check the utility and its support to ensure they do not affect the structural integrity or aesthetic appearance of the culvert.

13.4. APPROACH ROAD / EMBANKMENT

Approach Road / Embankment				
		Last	Now	Explanation of Condition
Horizontal Alignment				
Vertical Alignment				
Roadway Width (m)				
Embankment				
Sideslope (_ : 1)				
Height of Cover (m)				
Guardrail (Y/N)				
Approach Road/Embankment General Rating				

The length of the approach road to be evaluated by the bridge inspector is 1 km measured in either direction from the culvert. Refer to section 6.1 for more general information on approach roads.

13.4.1. Horizontal Alignment

Refer to section 6.2 for more details.

13.4.2. Vertical Alignment

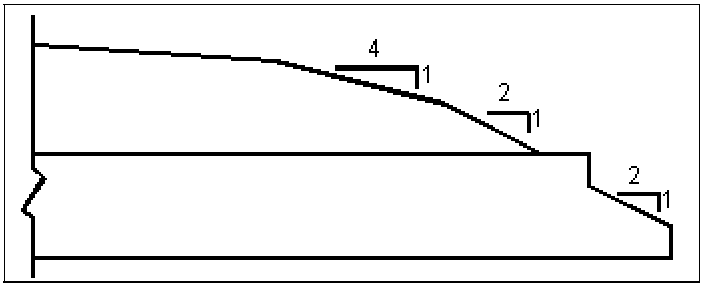
Refer to section 6.3 for more details.

13.4.3. Roadway Width

13.4.3.1. Background

The roadway width refers to the width of the approach road, which consists of the traveled lanes and the shoulders. Shoulders are located adjacent to the travel lanes and must be structurally adequate for all weather and traffic conditions. The transition or rounding between the outside edge of the shoulder and the sideslope is not included.

When recording the sideslope of the embankment, the steeper of the upstream and downstream sideslope is to be recorded on the form. If the upstream and downstream sideslopes are different, indicate in the 'Explanation of Condition' which side has been recorded.



On an embankment with a berm, the steepest slope either above or below the berm is recorded. The two slopes should not be averaged. Embankments with berms or varying sideslopes must also be described in the 'Explanation of Condition'.

Figure 13.3 - Roadway Embankment Sideslopes Over Culverts

13.4.3.2. Inspection and Coding Procedures

- Look for cracks or other evidence of instability in the roadway, sideslopes, and end transitions.
- Look for signs of erosion such as gullying along the sideslopes.
- Check toe of sideslopes and end transitions for erosion/scour.
- Estimate and note the slope of the sideslopes (horizontal: vertical). The steeper of the upstream or downstream sideslope should be noted.

13.4.3.3. Rating Guidelines

- Embankments with erosion problems, rate 4 or less.
- Embankments with stability problems that may affect the roadway surface, rate 3 or less.

13.4.4. Height of Cover

The height of cover is defined as the average vertical distance between the top of the roadway (centerline) and the top (crown) of the culvert and is measured to the nearest 0.1 m.

13.4.5. Guardrail

The ends of culverts, including those with retaining walls, can be hazardous to traffic. As such, guardrails or other types of railing are generally installed along the outside edge of the shoulders to create a safer driving environment. If guardrails exist along both shoulders, the inspector should record Y in the field provided. Additional notes are required if guardrails are installed along one shoulder only, or if they are too short or ineffective.

13.4.6. Approach Road General Rating

The approach road general rating is governed by:

- horizontal alignment rating
- vertical alignment rating
- embankment rating of 3 or less

13.5. UPSTREAM / DOWNSTREAM ENDS

Upstream End OR Downstream End				
Culvert Component		Last	Now	Explanation of Condition
Direction				
End Treatment (Concrete, Steel, Others, None)				

It is difficult to determine which culvert end is upstream or downstream in non-flowing streams and in winter inspection conditions. The inspector is to provide a direction in the fields provided for both the upstream and downstream ends of a culvert.

For non-flowing cattlepass structures, the inspector is to face the direction of increasing chainage, either north or east. The left side is labelled the upstream end and the right side is the downstream end. These directions are recorded in the fields provided.

13.5.1. End Treatment

The material type of end treatment (Concrete, Steel, Others or None) should be verified or recorded. A culvert with a square end and no end treatment is recorded as None. A steel, concrete or timber culvert with a bevel end, but no other end treatment, is recorded as Steel, Concrete or Other respectively. A steel or concrete culvert with concrete end treatment would be recorded as Concrete. A timber culvert with timber end treatment would be recorded as Other.

End treatment may include one or more of the following features: headwall, collar/concrete slope protection, wingwalls, cut off walls, bevel ends, and erosion/scour protection systems. The choice of end treatment usually depends on the type and location of the culvert and the hydraulic design. End treatments are used for one or more of the following reasons: improved aesthetics and hydraulic efficiency, prevent undermining due to scour, prevent erosion/scour of the embankment and/or stream banks, reduce piping through the structural fill and bedding, resist uplift, shorten the culvert, and stiffen the ends of flexible culverts.

In some cases, the upstream end treatment may include a system for trapping and deflecting drift during flood.

Inlet/outlet slabs on concrete box culverts are rated either with the floor of the culvert barrel or with the culvert end wingwalls. Wingwalls are differentiated from concrete bevel ends by connectivity to the barrel section. If the culvert end is not connected to the barrel section, the end is classified as a wingwall and the inlet/outlet slab acts as a strut and is therefore rated with the wingwall. If the culvert end is connected to the barrel section, the end is classified as a bevel end and the inlet slab is rated with the floor of the culvert barrel.

13.5.2. Headwall

Upstream End OR Downstream End			
Culvert Component	Last	Now	Explanation of Condition
Headwall			

13.5.2.1. Background

Headwalls are generally constructed from concrete, timber, or steel. They are located over the crown of the pipe and are usually attached to the barrel. They are used on culverts for aesthetics, strengthening of the ends, and resisting buoyancy forces. In some situations they may be used as retaining walls.

13.5.2.2. Inspection and Coding Procedures

- Look for signs of movement, tilting, and loose connections.
- Check concrete for cracks and deterioration.
- Check the stream-side face of concrete headwall for evidence of stains.
- Check timber for decay, missing planks, and gaps between planks.
- Check steel components for rust.
- Determine the effectiveness of the design as related to functionality and aesthetics.
- The rating should reflect the condition of the headwall, including all connections, as well as any defects that may reduce its aesthetics.

13.5.2.3. Rating Guidelines

- Defects which affect the functionality of the headwall, rate 4 or less.

13.5.3. Collar

Upstream End OR Downstream End			
Culvert Component	Last	Now	Explanation of Condition
Collar			

13.5.3.1. Background

Collars are generally constructed from concrete and are used around beveled slopes of flexible culverts, starting at the cutoff wall and ending at the headwall. In some cases, they are used independently of the headwalls and the cutoff wall. Their advantages include aesthetics, shortening the bevel, resisting buoyancy forces, and increasing the hydraulic efficiency of the culvert.

13.5.3.2. Inspection and Coding Procedures

- Check the effectiveness of the collar.
- Look for cracks, deterioration, and loose connections to the barrel or bevel.
- Rate the condition of the collar and its ability to function as originally designed.

13.5.3.3. Rating Guidelines

- Collars that are not connected to the culvert, rate 4 or less.

13.5.4. Wingwalls

Upstream End OR Downstream End			
Culvert Component	Last	Now	Explanation of Condition
Wingwalls			
(Shape :)			

13.5.4.1. Background

In general, wingwalls are constructed with concrete or steel at the ends of culverts that do not have bevels. They are either parallel or flared with respect to the culvert axis but are not permanently attached to the barrel. The parallel wingwalls require less scour protection between them, but are less efficient hydraulically than flared wingwalls. These wingwalls are also designed to retain the embankment material.

The toe of the wingwall is susceptible to scour/erosion which generally causes instability. In some cases, a reinforced concrete slab is constructed between the wingwalls to prevent scour/erosion and sometimes to act as struts and/or cantilevers for increased stability.

13.5.4.2. Inspection and Coding Procedures

- Check the vertical alignment and look for evidence of movement.
- Check the connections to the headwall.
- Check the gap between the wingwall and the barrel and determine if the separation is acceptable or if there may be problems due to the void between the wingwall and the barrel.
- Look for evidence of scour/erosion along the toe.
- Check concrete wingwalls for cracks and deterioration. Where a concrete slab exists between the wingwalls, the rating should include the condition and effectiveness of the slab.
- Check steel wingwalls for corrosion and loose connections.
- Record or verify shape of wingwalls as flared or parallel.
- Rate the worst of the wingwalls.

13.5.4.3. Rating Guidelines

- A wingwall that requires maintenance, rate 4 or less.
- A wingwall that has separation from the culvert barrel that may cause loss of fill, rate 4 or less.

13.5.5. Cutoff Walls

Upstream End OR Downstream End			
Culvert Component	Last	Now	Explanation of Condition
Cutoff Wall			

13.5.5.1. Background

Cutoff walls are generally constructed of concrete or steel. They are built vertically and are located at the ends of culverts. They extend from the culvert invert to a depth which exceeds the elevation of the bottom of the rock or concrete apron. The type and depth chosen usually depends on its intended function. For example, a deep cutoff wall will reduce undermining and piping, and if constructed of concrete, will also resist buoyancy forces.

In many cases, it is difficult to inspect cutoff walls since they are submerged or covered with ice or debris.

13.5.5.2. Inspection and Coding Procedures

- Look for evidence of undermining, piping, or uplift.
- Check the connections of the cutoff wall with the culvert invert.

13.5.5.3. Rating Guidelines

- If the cutoff wall cannot be inspected, rate N.
- If the cutoff wall is separated from the culvert, rate 4 or less.
- If the inspector is certain that no cut-off wall exists, rate X.

13.5.6. Bevel End

Upstream End OR Downstream End				
Culvert Component		Last	Now	Explanation of Condition
Bevel End				
Heaving (mm)				
Invert Above/Below Stream Bed				
Above/Below (mm)				

13.5.6.1. Background

For the purpose of this manual, bevel ends are classified as:

a) Sloped bevel if the sloped section starts at the top of the crown and ends at the invert.

b) Step bevel if the sloped section starts below the crown and ends above the invert. They are permanently attached to the barrel and are generally parallel to the culvert axis. Bevel ends are more attractive, economical, and hydraulically more efficient than projecting ends. However, steel bevels are more flexible and thus tend to deform when exposed to lateral forces from the surrounding material, and/or heave due to buoyancy forces or frost action.

Heaving

Steel bevel ends are flexible and tend to deform under lateral forces from the surrounding material. These forces can be caused by buoyancy forces or frost action. If there are signs of heaving, estimate and record the amount. The inspector should not confuse negative camber with bevel heaving.

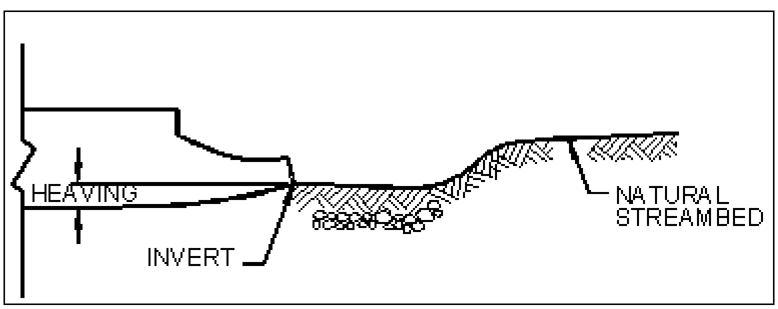


Figure 13.4 - Bevel Heaving

Invert Above/Below Streambed

This is a measurement of whether the invert of the culvert is above or below the natural streambed. The measurement is taken by finding a representative natural streambed location and comparing it to the invert. The measurement should not be taken right at the end of the culvert since scour holes are typically found at this location. Using a hand held level helps determine this measurement.

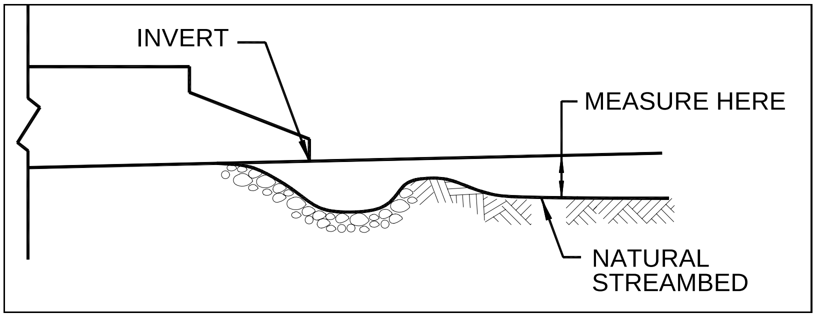


Figure 13.5 - Invert Above Streambed

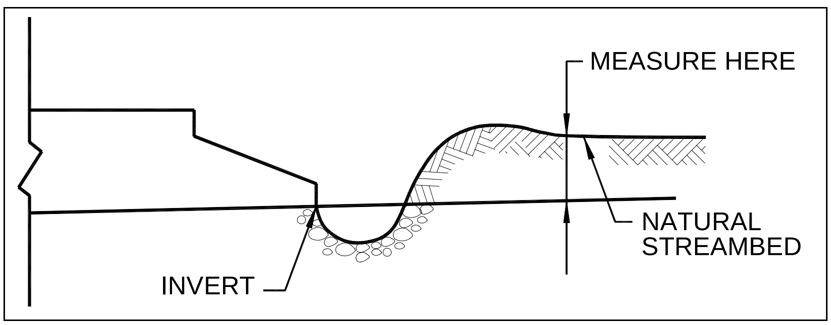


Figure 13.6 - Invert Below Streambed

13.5.6.2. Inspection and Coding Procedures

- Check bevel along the sloped edge for deformation.
- Check bevel section, including invert plates for signs of heaving. Estimate the amount of heaving and note on the BIM form. One guide to estimate the amount of heaving is to compare waterline to longitudinal seams if they exist.
- Look for signs of corrosion and abrasion.
- Estimate and note the depth of the invert end above or below average streambed elevation.
- The rating should be based on the condition and functionality of the bevel end only.

13.5.6.3. Rating Guidelines

- If no bevel exists, rate X (square end).
- If the defects or deformation do not affect the culvert aesthetics or performance, rate 6 or less (e.g. a bevel end with no fill along the sides, but no heaving or condition or functionality problems).
- If corrosion is severe enough to affect the strength and functionality of the bevel, rate 4 or less. Otherwise the coating condition should not affect the functionality and rating of the bevel.

13.5.7. Scour Protection

Upstream End OR Downstream End

Upstream End OR Downstream End				
Culvert Component		Last	Now	Explanation of Condition
Scour Protection				
(Type :)				
(Avg. Rock Size (mm) :)				

13.5.7.1. Background

One of the design considerations for culverts located on streams with erodable beds and banks, is to ensure that the velocities and eddies at the ends are adequately handled with an erosion protection system. In many cases, heavy rock rip-rap of sufficient size and proper gradation is used. Often, the designer specifies the minimum requirements to provide some assurance against extensive damage during major floods and expects the bridge inspector will determine if more protection is required. Inadequate protection, especially on the downstream end, may result in undermining of the culvert, development of large and deep scour holes which may induce slumps and slides, and the formation of sandbars which may reduce the hydraulic efficiency of the structure.

In some cases, concrete scour protection is used in combination with concrete collars. The concrete scour protection provides scour protection for the embankment and has the added advantage of minimizing piping through the structural fill.

13.5.7.2. Inspection and Coding Procedures

- Note or verify the type of scour protection.
- Note or verify the average size of the rock protection and look for signs of rock displacement.
- Check the thickness of the rock layer as well as the gradation of the rocks, when possible.
- Check the rocks to determine if they have started to disintegrate.
- On grade separation culverts or stock passes, rate the quality and effectiveness of the rocks along the cut slopes.

- Check the effectiveness of the concrete scour protection. Look for evidence of piping and scour/erosion.
- Rate the condition of the concrete scour protection and its ability to function as originally designed.

13.5.7.3. Rating Guidelines

- As a general rule, the scour protection rating should not be greater than the scour rating if it is less than 5. In this situation, a scour problem has been identified and rated below acceptable condition and functionality. It follows that the scour protection is not adequately functioning and therefore cannot be rated higher than the scour rating.
- If the protected areas are smaller than required and/or the gradation and quality of the rocks are inadequate, rate the scour protection 4 or less. If there are no signs of scour or erosion, the scour rating could be higher than 4 but the scour protection rating should remain at 4 or less.
- Concrete scour protection that has excessive settlement or is undermined, rate 4 or less.
- If no scour protection exists and none is required, rate the protection 7 or more and note the type as Natural.
- If no scour protection exists but is required, rate the protection 4 or less and note the type as None and make recommendation for scour protection.
- If there are no signs of scour/erosion that may affect the culvert, and no evidence of displacement or deterioration, rate 7 or more.
- If a cattlepass also carries water flow, the inspector is to rate scour and scour protection. Otherwise, these elements are to be rated X for cattlepasses.

13.5.8. Scour / Erosion

Upstream End OR Downstream End			
Culvert Component	Last	Now	Explanation of Condition
Scour/Erosion			

13.5.8.1. Background

Scour/erosion refers to the removal of material from the streambed and/or bank by the erosive action of the stream flow. It is classified as:

a) general scour which is a uniform lowering of the original streambed
b) local scour which occurs at specific locations such as along culvert footings and wingwalls

Scour at culvert outlets is a common condition, and if undetected may undermine the culvert, initiate slumps or slides, adversely affect the culvert hydraulics, and impede fish passage. The failure and/or inefficient operation of many bridge size culverts located on a stream with erodable streambed and banks can be traced to scour/erosion.

13.5.8.2. Inspection and Coding Procedures

- Check the areas in vicinity of culvert footings, wingwalls, collars, cutoffs, and the ends of the protection system.
- Look for scour holes within rock rip-rap protection systems.
- Look for signs of undermining of transition slopes and stream bank.
- Check areas where the stream flow impinges on the banks or protection system.
- The rating should include the adverse effects of scour/erosion on the culvert, embankment material, streambed, and banks.

13.5.8.3. Rating Guidelines

- If the culvert and the embankment material are not affected, rate 5 or more.
- If there is any form of scour or erosion that may affect the culvert, rate 4 or less.

13.5.9. Beavers

Upstream End OR Downstream End			
Culvert Component	Last	Now	Explanation of Condition
Beavers (Y/N)			

13.5.9.1. Background

Beaver dams around culverts are almost impossible to eliminate completely unless the beaver population is reduced or removed. Problems caused by beaver dams include flooding, washouts, and culvert blockage.

13.5.9.2. Inspection and Coding Procedures

- Note Y if beaver dam exists at a location in or near the culvert that would affect the integrity and operation of the culvert and describe location and extent of problem in ‘Explanation of Condition’.

13.5.10. Upstream / Downstream Ends General Rating

The culvert end general ratings are governed by:

- headwall rating
- collar rating
- wingwall rating
- cutoff wall rating
- bevel end rating
- scour protection rating
- if all elements are rated X, then provide a general rating based on the overall condition of the culvert end.

13.6. Barrel Section

13.6.1. Introduction

The barrel is the section of the culvert that is completely enclosed for round or elliptical pipes and includes the roof and sidewalls for arches and box pipes with no floors. The length of the barrel is equal to the length of the crown. The size of the opening is based on hydraulic parameters and the wall thickness is designed to carry all or part of the imposed loads.

Rigid culverts (timber and concrete) are generally more expensive than flexible (steel) culverts but are more durable and require less structural maintenance. Their design and installation are based on proven engineering principles and construction methods. Consequently, structural problems with the barrel of rigid culverts are rare.

Flexible culverts are more economical, but are more susceptible to problems such as excessive deflection, buckling, seam failure, corrosion, and abrasion. Their performance is difficult to predict since it depends on a complex soil-steel interaction system and the installation techniques used. Under ideal situations the barrel is required to carry a small percentage of the imposed loads. Unfortunately, this is not always the case, since the barrel can be subjected to high stresses during assembly, backfilling, and compaction throughout its service life. Also, the stress intensity in the barrel may change in time due to thinner steel section caused by corrosion or abrasion, loss of support due to piping, movement of smaller size material in the structural fill, increased live loads, development of negative arching caused by transverse differential settlement, reduced seam strength caused by cracks or deformation, gradual loss of shape, etc. To avoid problems in these situations, the metal section and the seams must still have enough strength to resist ring compression stresses and excessive deflections. Signs of distress such as distortion, deflection, and cracks must be noted and supplemented with measurements and photographs so that the culvert can be monitored for further changes.

Structural Plate Corrugated Steel Pipes (SPCSP) consists of steel plates with circumferential and longitudinal seams. The section between two circumferential seams is referred to as a ring. The rings of a culvert are numbered starting at the upstream end of the barrel, excluding the bevel. If the culvert is not a stream crossing, the upstream end will be taken as the left end when looking in the direction of increasing highway chainage, from west to east or from south to north.

Bridge Culvert Barrel			
Culvert Component	Last	Now	Explanation of Condition
(Pipe # : ,Primary/Secondary Span, Location Code: , Span (mm): , Rise (mm) : , Type :)			
Barrel Last Accessible Date			

The first line of the culvert barrel section contains inventory information for the particular barrel section being inspected. For culverts with multiple barrel sections, each barrel section will contain the inventory information for that particular barrel. The next line of the section contains a field for ‘Barrel Last Accessible Date’. If the barrel is accessible during an inspection, the date recorded is the current date of inspection. If the barrel is not accessible, the previous recorded date is to remain.

13.6.2. Inaccessible Barrel Sections

When the barrel section of a culvert is inaccessible, the barrel elements are rated N unless an obvious defect is noted.. Previous comments are retained for information by putting brackets around the comments or parts thereof that cannot be verified and adding the date the comment originated. The inspector should note in the ‘Explanation of Condition’ the culvert was viewed from the ends (if possible) and the condition as viewed from the ends should be recorded (i.e. general shape and condition – good/adequate/fair/poor).

For culverts where the barrel section is inaccessible and the critical elements are rated N the general rating may be rated N or the previous general rating may be carried over. If a critical barrel element was previously rated 4 or less, resulting in a general rating of 4 or less, the previous general rating must be carried over. A comment must be provided in the ‘Explanation of Condition’ indicating this. On the other hand, if the previous critical element ratings resulted in a general rating of 5 or greater, the general rating should be N. This is done because if the culvert barrel general rating is N, the system defaults to a general rating of 5 for the calculation of the Structural Condition Rating. Additionally, if the general rating on the previous inspection was rated N and the general rating on the current inspection is rated N, the inspector must review the previous inspections for when the culvert barrel was last accessible for inspection and confirm that the N rating has been carried forward correctly.

If the barrel is inaccessible but an obvious defect is visible from the end, the element is rated accordingly and another inspection should be scheduled during low flow conditions to thoroughly inspect the element. For example, the roof may show signs of distress and the previous rating indicates it was adequate. The roof should be down rated with comments in ‘Explanation of Condition’.

13.6.3. Special Features

Bridge Culvert Barrel			
Culvert Component	Last	Now	Explanation of Condition
Special Features			
Special Features			
(Type :)			
Special Features			
(Type :)			

13.6.3.1. Background

Special features on culverts are listed under the barrel section of the inspection form. These are culvert elements that are unique to a particular culvert and cannot be rated under any other element. It is necessary to record the type of special feature and provide a condition rating for the element. These elements may be temporary or permanent features of the culvert.

Some examples of special culvert features are:

- timber or steel struts in the barrel section
- abrasion plates on the floor
- shotcrete beam
- culvert liner
- concrete floor slab
- de-icing devices
- any instrumentation devices used for monitoring performance

13.6.3.2. Inspection and Coding Procedures

- Check for common defects and damage as noted in section 7.1.
- Note the type of element and provide a condition rating.
- Use the 'Explanation of Condition' space to note additional information such as location, dimensions, and condition of element.

13.6.4. Roof

<table>
<tr><th colspan="5">Bridge Culvert Barrel</th></tr>
<tr><td colspan="2">Culvert Component</td><td>Last</td><td>Now</td><td>Explanation of Condition</td></tr>
<tr><td colspan="2">Roof</td><td></td><td></td><td rowspan="5"></td></tr>
<tr><td>Measured Rise (mm)</td><td></td><td colspan="2"></td></tr>
<tr><td>Measured at Ring No.</td><td></td><td colspan="2"></td></tr>
<tr><td>Sag (mm)</td><td></td><td colspan="2"></td></tr>
<tr><td>Percent Sag</td><td></td><td colspan="2"></td></tr>
</table>

13.6.4.1. Background

This item evaluates the condition and changes in design dimensions of the top horizontal portion of box culverts, top arcs of non-round culverts, and the top portion of round culverts defined by a central angle of about 120 degrees. The rating of the roof is made independently of the rest of the barrel. It includes consideration of cracks, decay, distortion, deflection, defective joints, and degree of corrosion. The rating must reflect the ability of the roof to transfer external loads to the sidewalls and to prevent backfill material from entering the opening.

13.6.4.2. Reverse Curvature in Metal Culverts

A metal culvert has low bending strength and depends on its curved shape to carry loads in ring compression. Inward deformation of the curved shape can significantly change its ability to carry loads and support the roadway over the top of the culvert. If the culvert has deformed to the point where the curvature of the plate is reversed (see Figure 13.7) the culvert ring at this location has, in theory, very little capacity to carry loads in ring compression and has potential to collapse. Therefore, reverse curvature in a metal culvert is a serious defect and should be rated 2 or less.

Figure 13.7 - Culvert Roof with Reverse Curvature

Experience and judgment is required to distinguish between a rating of 1 or 2. The inspector needs to consider such factors as the length of the section of culvert with reverse curvature, the height of the fill over the culvert, and the original design shape of the culvert. Reverse curvature in one ring is not as serious as reverse curvature over a large number of rings. Soil arching (distribution of load through the soil) occurs over culverts and a culvert with a large height of fill relative to its span has less risk of collapse than a culvert under shallow fill. A relatively flat horizontal ellipse is more sensitive to a slight reverse curvature then a round culvert.

13.6.4.3. Inspection and Coding Procedures

- On timber culverts look for signs of decay, especially around connections and bearing areas. Also, check for loss of backfill through openings between stringers.
- On concrete culverts, look for cracks, exposed reinforcement, and signs of deteriorated concrete.
- On flexible culverts check roof for distortion, deflection, improperly nested or cracked seams, and signs of corrosion.
- When evaluating reverse curvature document length of reverse curvature along barrel. Measure the maximum deformation from original shape in mm and the height of cover over the area with reverse curvature.
- Check for sag in roadway due to distortion of roof.
- The presence of temporary (less than 2 yrs.) repair measures should not influence the rating.
- At worst location, measure/estimate and note the amount of sag or distortion, whether upward or downward. If the deflection is upward, note it in ‘Explanation of Condition’ column. For corrugated metal culverts, all measurements should be

from the inside crest to inside crest (see section 13.6.7 for more details on determining roof sag).

- Calculate and record percentage sag.

13.6.4.4. Rating Guidelines

- See Table 13.3 for detailed rating information.
- A roof with some superficial rust, less than 5% deflection/distortion of the design rise or the average rise of the end rings, and properly nested seams without cracks, rate 6 or more.
- A roof with rust perforations, more than 10% deflection/distortion of the design rise or the average rise of the end rings, or cracked longitudinal seams, rate 3 or less.
- A roof with extensive rust perforations, rate 2.
- Cracked longitudinal seams with less than 50 mm of steel remaining between the ends of cracks, rate 2 or less.
- Reverse curvature, rate 2 or less.
- Reverse curvature combined with shallow cover, rate 1.
- If there is evidence of significant settlement of roadway or other signs of impending failure in conjunction with reverse roof curvature, rate 1.
- When determining the roof rating, consideration must be given to the rating assigned to the longitudinal and circumferential seams which form part of the roof. For example, a cracked seam in the roof area rated 2, will result in the roof rating also being rated 2.

13.6.5. Sidewall

Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
Sidewall				
Measured Span (mm)				
Measured at Ring No.				
Deflection (mm)				
Percent Deflection				

13.6.5.1. Background

The rating considerations for this item are similar to those noted in section 13.6.4 Roof. The sidewall that is in the worst condition should be rated.

The sidewall is defined as the portion of the barrel that is located between the roof/top arc and the floor/bottom arc. Its primary function is to transmit loads to the floor/bottom arc and for flexible culverts, to transfer loads to the structural fill through soil-steel interaction. It also functions like a retaining wall and prevents backfill material from entering the opening. The sidewalls on flexible culverts can deflect inward or outward, depending on the magnitude of the applied loads and the strength and stability of the structural fill. This movement is inevitable for the barrel to reach a load sharing equilibrium with the structural fill.

13.6.5.2. Inspection and Coding Procedures

- On timber culverts look for decay, broken or missing timber, crushing, deterioration, and loss of backfill through openings between the timber.
- On concrete culverts look for cracks and evidence of concrete deterioration.
- On flexible culverts, check sidewall for deflection, signs of crimping or buckling, improperly nested or cracked seams, and signs of corrosion and abrasion.
- At worst location, measure/estimate and note the amount of deflection, inward or outward. If the deflection is inward, note it in 'Explanation of Condition'. For corrugated metal culverts, all measurements should be from the inside crest to inside crest (see section 13.6.7 for more details on determining deflection).
- Calculate and record the percentage deflection.
- Condition rating should not include the effects of temporary repairs.

13.6.5.3. Rating Guidelines

- See Table 13.3 for detailed rating information.
- Sidewalls with some superficial rust and abrasion, less than 5% deflection of the design span or the average span of the end rings, no evidence of crimping or buckling, and no cracks in the longitudinal seams, rate 6 or more.
- Sidewalls with rust perforations, more than 10% deflection of the design span or the average span of the end rings, signs of crimping or buckling, or cracked longitudinal seams, rate 3 or less.
- A sidewall with extensive rust perforations, deflection exceeding 15% of the design span or the average span of the end rings, crimping or buckling that shears the plates, and/or cracked seams with less than 50 mm of steel remaining between the ends of cracks, rate 2 or less.
- When determining the sidewall rating, consideration must be given to the rating assigned to the longitudinal and circumferential seams which form part of the sidewall. For example, a cracked seam in the sidewall area rated 2, will result in the sidewall rating also being rated 2.

13.6.6. Floor

Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
Floor				
Bulge (mm)				
Measured at Ring No.				
Abrasion (Y/N)				

13.6.6.1. Background

The floor refers to the bottom horizontal portion of box culverts, bottom arcs of non-round culverts, and the bottom portion of round culverts defined by a central angle of about 120 degrees. The rating consideration for this item includes those noted in section 13.6.4 Roof, and the effects of abrasion, especially for steel floors. Abrasion is caused by the movement of the streambed and streambank material through the culvert. This phenomenon results in the removal of the protective coating and wearing off of the core metal, thus causing accelerated corrosion and reduced strength of the floor.

The floor serves to transmit loads to the foundation and prevents scouring within the culvert. Culverts designed without floors depend on footings and/or piles for load transfer and an erosion protection system to prevent excessive scour.

13.6.6.2. Inspection and Coding Procedures

- Check floor for abrasion, cracks, and bulging. Estimate and record the amount of bulging as well as its location.
- Check timber floors for decay, missing timber, and loose connections.
- Check steel floors for signs of crimping or buckling, defective seams, and corrosion.

13.6.6.3. Rating Guidelines

- See Table 13.3 for detailed rating information.
- Floors with minor abrasion, little superficial rust, less than 5% bulging of the as-installed rise or the average rise of the end rings, and no signs of buckling or defective seams, rate 6 or more.
- Floors with extensive rust perforations or abrasion, rate 3 or less.
- When determining the floor rating, consideration must be given to the rating assigned to the longitudinal and circumferential seams which form part of the floor. For example, a cracked seam in the floor area rated 3, will result in the floor also being rated 3.

13.6.7. Roof Sag, Sidewall Deflection and Floor Bulge Measurements

To record Roof Sagging and Sidewall Deflection, measure the rise and span and compare them to the original design dimensions given on the inspection form. Record the differences in the Sagging and Deflecting fields. If the floor has bulged, record this separately in the Floor Bulging field and exclude the effects from the Sagging measurement.

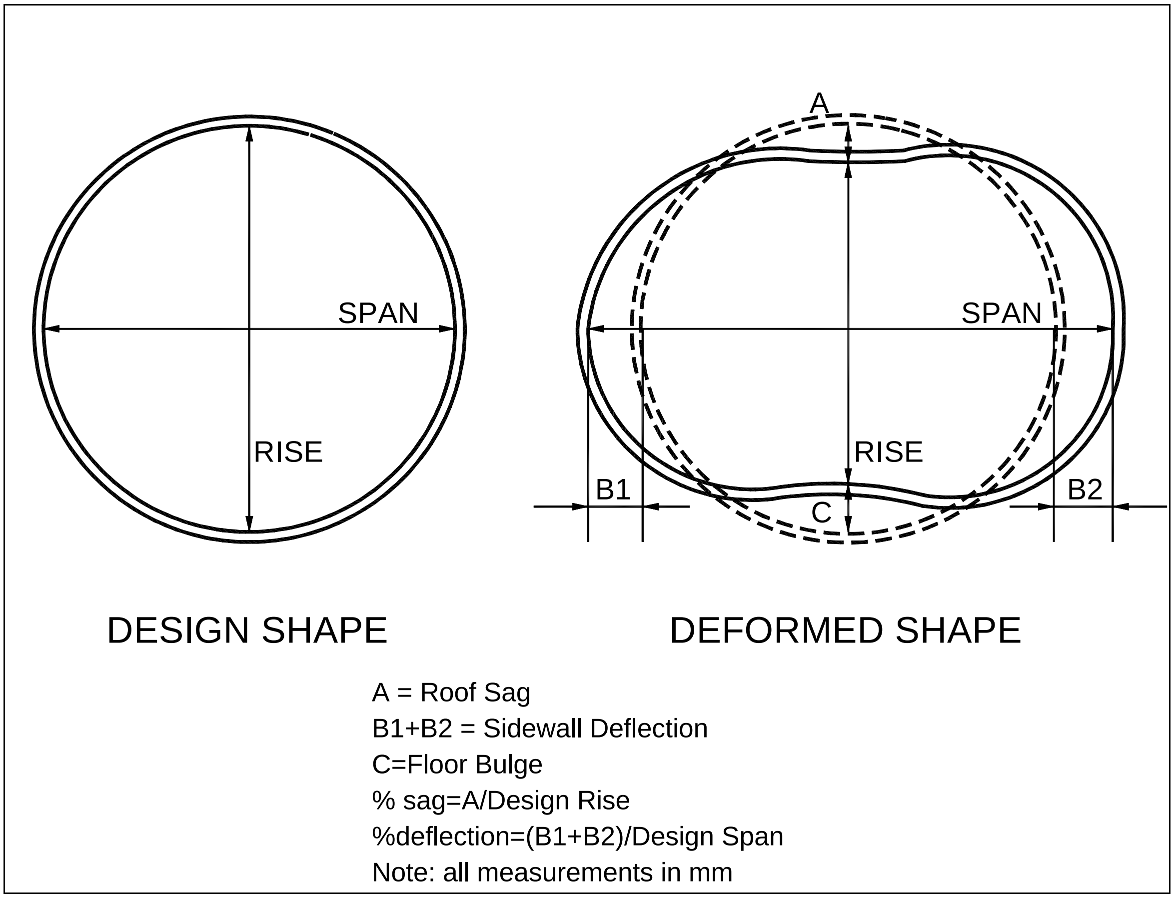


Figure 13.8 - Deformed Culvert Shape Measurements

The measurements are taken at the location of worst deformation. The same location may not necessarily apply for determining the maximum vertical roof sag and horizontal sidewall deflection and floor bulge. In the fields provided in the roof and sidewall sections record the following:

- actual rise and span measurements
- ring number from U/S where measurements taken (In the case of CSP note distance from U/S end)
- sag and deflection
- percentage deformation relative to the design dimension

When the culvert barrel is in good condition and the ratings of the critical elements such as roof, sidewall, and seams are rated 7 or more, measurements are not required. Conversely, where the roof or sidewall deflection is greater than 5%, the location should be measured and marked with a permanent mark (paint) to enable future measurement at the same location for comparison purposes.

13.6.8. Circumferential Seams

Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
Circumferential Seams				
Separation (mm)				

13.6.8.1. Background

Circumferential seams are used to connect various lengths of culverts, resist separation of adjoining sections, and to prevent infiltration of backfill material. Defective seams may adversely affect the hydraulic and structural performance of the culvert. In concrete culverts they exist as construction joints, in CSP they are referred to as coupling systems, and in SPCSP they are called bolted seams. Problems with circumferential seams are more common with CSP culverts (see Figure 13.9). They are generally caused by longitudinal differential settlement, improper coupling system or installation methods, and/or gradual downstream movement of the culvert barrel. Circumferential seams in a SPCSP structure are not as critical as the longitudinal seams.

Figure 13.9 - Separated Circumferential Seam

13.6.8.2. Inspection and Coding Procedures

- Look for signs of misalignment between adjoining sections.
- Check seams for evidence of infiltration of backfill material caused by improper connections or separation of adjoining sections (see Figure 13.9).
- Record the size and note location of maximum separation on the BIM report.
- Look for cracks around bolts holes due to improper or over torquing of the bolts.
- Look for cracking especially at the 12:00 o'clock position in SPCSP culverts with substantial sagging of the roof.

13.6.8.3. Rating Guidelines

- If misalignment or separation exists to cause infiltration of soil, rate 4 or less.
- If there is cracking around the bolt holes due to improper or over torquing of the bolts and there is no problem associated with this cracking, rate 5.
- If there is cracking due to roof sagging, rate 4 or less.

13.6.9. Longitudinal Seams

Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
Longitudinal Seams				
Total No. of Cracked Rings				
Total No. Rings with Two Cracked Seams				
Min. Remaining Steel Between Cracks (mm)				
Proper Lap (Y/N)				
Longitudinal Stagger (Y/N)				

13.6.9.1. Background

This item applies to SPCSP and Riveted CSP culverts only. The longitudinal seams in SPCSP and riveted CSP culverts are designed to carry the full ring compression in the culvert. They are also required to keep the plates together and aligned and prevent infiltration of the backfill material. In theory the longitudinal seams should only transfer ring compression stresses. The bolted seam is not designed for bending and has only approximately 75% the bending strength of the plates. However, in practice, for various reasons, these longitudinal seams are subjected to bending stresses. Therefore, it is preferable if the longitudinal seams of the culvert do not occur at the same line along the pipe. For this reason, the longitudinal seams of the culvert rings are often staggered.

The strength of the seams is further reduced if one or more of the following defects exist:

a) cracked bolt holes - caused by excessive bending strains, improper lapping of plates, and perhaps over-torquing of bolts

b) bolt tipping - caused by high ring compression forces that cause slippage between plates and/or plastic elongation of the bolt holes

c) plate distortion - caused by high ring compression forces, improper assembly and backfilling procedures

d) cusping - caused by poor backfill material and compaction, improper fabrication, and poor assembly procedures

e) improper nesting - caused by improper fabrication and poor assembly procedures

f) corrosion of bolts or rivets - caused by soil and/or water

It should be noted that defects in two or more seams within the same barrel section may cause catastrophic failure of the culvert.

13.6.9.2. Inspection and Coding Procedures

- Check for cracked bolt holes, especially on improperly lapped seams located in the sidewalls. A properly lapped seam is one with the bolts in the valley nearer to the visible edge of the plate than the bolts in the crest. If cracks are found, the ends of the cracks should be marked and dated. The minimum remaining steel between cracks of bolt holes should be measured and recorded and the location noted in 'Explanation of Condition' (see Figure 13.11).
- Check seams for bolt tipping, distortion, cusping, improper nesting, and signs of corrosion.
- Record the total number of rings with cracked seams on the form and note the locations in the 'Explanation of Condition'.
- Record the total number of rings with cracks in two (or more) longitudinal seams and note locations in 'Explanation of Condition'. Two or more cracked seams within the same barrel section may cause catastrophic failure of the culvert.
- Record or verify if seams are properly lapped.
- Note if the seams are staggered longitudinally for round culverts, and within the individual arcs for non-round culverts.

13.6.9.3. Rating Guidelines

- A culvert with all seams properly lapped with no defects, rate 9.
- Seams without any defects and appears to be in excellent condition, but are improperly lapped, rate 7.
- If cracked seams exist, the seam should be rated 4 or less. If the cracked seam has less than 50 mm of steel remaining between the ends of the cracks, rate 2 or less.
- If two or more cracked seams are in the same ring, rate 2 or less.
- Riveted longitudinal seams in a CSP culvert are rated. The type can be noted in 'Explanation of Condition' as riveted.

Figure 13.10 - Properly Lapped Seam

Figure 13.11 – Improperly Lapped Seam with Longitudinal Cracks

13.6.10. Coating

Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
Coating				
Corrosion By Soil (Y/N)				
Corrosion by Water (Y/N)				

13.6.10.1. Background

This item is applicable to steel culverts only and rates the condition of the zinc or aluminum coating and any additional coating that may exist on the culvert. Photos of varying degrees of culvert corrosion are shown in Figure 13.12 to Figure 13.14.

A zinc or aluminum coating is applied to steel culverts to control and prevent corrosion which generally results in reduced load carrying capacity, infiltration of backfill material, and an unattractive appearance. Corrosion is initiated after the protective coating is removed, damaged, or perforated. The zinc coating sets up galvanic cells by sacrificing itself to protect the steel. Corrosion in culverts occurs from both the outside (soil side) and inside (water side). It is difficult to recognize corrosion on the outside until extensive damage in the form of rust perforations can be detected from the inside. Corrosion caused by water usually begins on the invert plates, which are susceptible to abrasion.

13.6.10.2. Inspection and Coding Procedures

- Check barrel for fabrication and installation defects such as blisters, foreign inclusions, uncovered surfaces, and damage to the protective coating.
- Check barrel for evidence of pitting and perforations.
- Check all abrasion areas, bolts, and areas around bolt holes for signs of corrosion.
- Rust stains through bolt holes and rust perforations in the top arc are signs of outside (soil) corrosion.
- Note Y if corrosion is from soil and/or water.

13.6.10.3. Rating Guidelines

- Extensive corrosion and pitting in roof and/or sidewalls, rate 4.
- Isolated perforations in floor, rate 4.
- Isolated perforations in roof and/or sidewalls, rate 3.
- Extensive perforations in floor, rate 3.
- Extensive perforations in roof and/or sidewalls, rate 2.
- Severe perforations in floor, rate 2.
- Severe perforations in roof and/or sidewalls, rate 1.

Figure 13.12 - Minor Corrosion, Rated 5

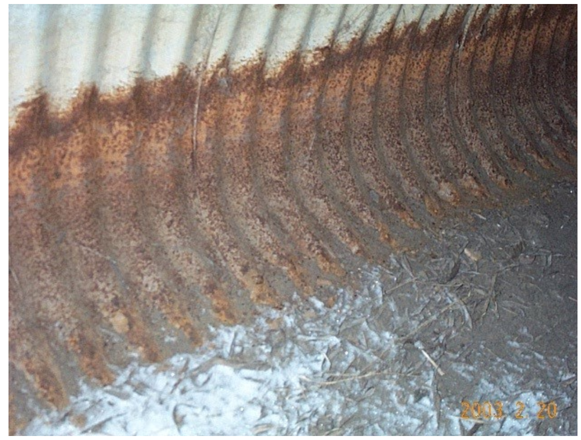


Figure 13.13 - Heavy Corrosion, Rated 4

Figure 13.14 - Severe Corrosion, Rated 2

13.6.11. Camber and Ponding

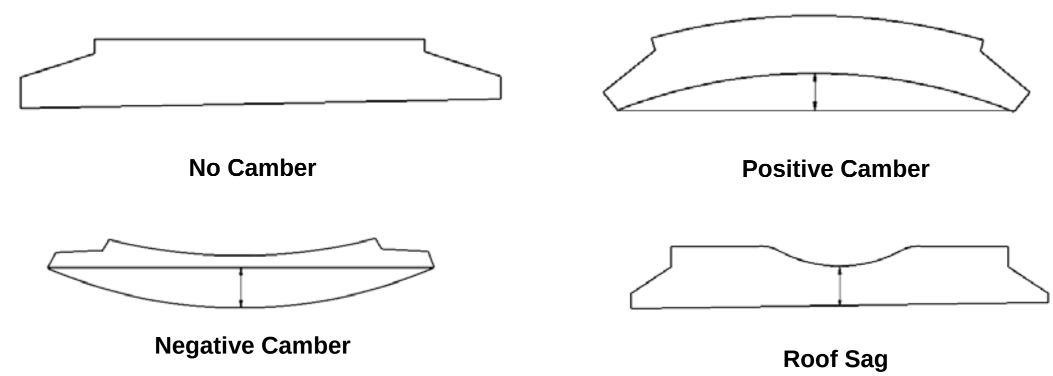
Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
Camber POS/ZERO/NEG				
Ponding (Y/N)				

13.6.11.1. Background

These items do not require a rating.

Camber

Camber is defined as a gradual vertical curve along the longitudinal axis of the culvert. The camber could be either POSITIVE, ZERO or NEGATIVE. Positive camber exists when the barrel section invert is above the gradeline between the upstream and down-stream inverts (crest curve). Culverts under high fills or on soft foundations are generally designed with a positive camber (i.e. crest curve), centered under the maximum height of cover to accommodate long term differential settlements. A negative camber exists when the culvert invert within the barrel section is below the grade between the upstream and downstream inverts (i.e. a sag curve along the invert of the barrel).



The inspector should not confuse negative camber with roof sag.

Figure 13.15 - Culvert Camber and Roof Sag

Ponding

An obstruction downstream of a culvert may create a backwater situation. The water level will increase upstream of the obstruction. If the accumulation of water within the culvert is to a depth that adversely affects the function of the culvert, record Y for ponding. This is of particular concern when the culvert serves as a cattlepass or an underpass.

13.6.11.2. Inspection and Coding Procedures

- Compare the elevation difference within the barrel between the closest seams on the SPCSP and the water surface to determine if positive or negative camber exists. If a camber is visible, record POS, or NEG. If barrel appears straight, record ZERO.
- Look for evidence of ponding which may be caused by negative camber or poor drainage at the ends of culverts used as underpasses or stockpasses. Record Y if ponding occurs.

13.6.12. Fish Passage Adequacy

Bridge Culvert Barrel			
Culvert Component	Last	Now	Explanation of Condition
Fish Passage Adequacy			
Baffle			
(Type :)			

13.6.12.1. Background

The inspector is required to rate the culvert barrel and both ends for their ability to accommodate fish passage. The inspector should assume that all culverts are fish bearing. It may be difficult for an inspector to rate fish passage since the ability to pass fish depends on many factors such as flow velocity, obstructions, etc. that change at different times. The inspector should rate what he sees at the time of inspection. A rating is required even if the stream is dry at the time of inspection. The inspector should note his logic for the rating in 'Explanation of Condition'.

Fish baffles are used in culverts that are located on fish bearing streams and when the velocities in the culvert may impede fish passage. In general, the velocities in the culvert are higher than those in the natural stream. The fish baffles are used to reduce the velocities by increasing the culvert roughness, to provide rest areas for the fish, and in the case of weir-type baffles they provide a minimum depth of flow during low flow situations. The types of baffles used are:

a) spoilers which may consist of precast concrete blocks attached to the invert
b) large boulders which may be attached to the invert if they can be displaced during peak floods
c) weirs which are located perpendicular or skewed to the flow

13.6.12.2. Inspection and Coding Procedures

- Record the type of baffles on the BIM form.
- Check concrete baffles and their fasteners for deterioration and damage.
- Check baffles consisting of large boulders for signs of disintegration, displacement, and loose fasteners.

13.6.12.3. Rating Guidelines

- Regardless of whether the stream is flowing or dry, culverts that appear adequately sized and are in line with or below streambed, rate 5 or better.
- Undersized culverts or those with the upstream or downstream end above streambed, rate 4 or less (see Figure 13.16).
- Culverts used as underpasses and stockpasses, rate X.
- If a cattlepass also carries water flow, the inspector is to rate fish passage. Otherwise, this is to be rated X.

Figure 13.16 - Culvert with Hanging Invert

13.6.13. Waterway Adequacy

Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
Waterway Adequacy				
Icing (Y/N)				
Silting (Y/N)				
Drift (Y/N)				

13.6.13.1. Background

Waterway adequacy refers to the ability of the barrel to pass the water flow and associated debris without damaging the culvert, or causing intolerable backwater. The efficiency of the opening is dependent on its size, as well as the hydraulic characteristics of the culvert, debris accumulation, ice build-up, and river control works.

Icing

Ice may build up within the barrel section of the culvert to the extent that it adversely affects the flow of water. In extreme cases, the ice may completely seal or block off the flow of water through the culvert. Answer the inventory question Y if the build up of ice affects the flow of water.

If a previous inspection was completed in the winter with an icing condition noted and described, leave the inventory question as Y and add the date the Y was recorded next to the previous comments in the ‘Explanation of Condition’.

Silting

Culverts are designed to be installed below streambed to a depth of 1/4 diameter to a maximum of 1 m. Therefore, some minor accumulation of silt material is expected in the bottom of the culvert. However, silt material may build up to an extent that it adversely affects the flow of water and possibly the passage of fish. Under high flow conditions, the accumulated material may reduce the flow area of the culvert and create backwater conditions upstream of the culvert. Under low flow conditions, the accumulated material may completely block the flow of water. Answer the inventory question Y only if the silt is adversely affecting the flow of water.

Drift

Since culverts generally restrict the opening of the stream, the accumulation of drift is often a problem at culverts. Drift reduces the capacity of the culvert and can create backwater conditions upstream. In high water conditions drift can completely block the flow of a culvert causing flooding upstream. Answer the inventory question Y if drift exists at culvert and note location and extend in 'Explanation of Condition'.

13.6.13.2. Inspection and Coding Procedures

- Check for reduction in size of the opening. Look for debris accumulation, siltation, stream migration, and repair measures within the culvert.
- Check upstream and downstream sides of the culvert for high water marks.
- Look for unusual scour at the upstream and downstream ends that may indicate the barrel is undersized.
- Look for new river engineering works in the vicinity of the culvert which may indicate there is a problem with the barrel's ability to pass required discharge.

13.6.13.3. Rating Guidelines

- An adequate opening, rate 5 or more.
- If the culvert opening has blockage of 50% or more due to restrictions of the barrel opening, rate 3 or less. In 'Explanation of Condition' note the type of blockage (e.g. icing, silting, drift, etc.).
- If a cattlepass also carries water flow, the inspector is to rate waterway adequacy. Otherwise, these elements are to be rated X.

13.6.14. Barrel - General Rating

The general rating of the culvert barrel is perhaps the most important rating the inspector has to provide for culverts. It reflects the current overall structural condition of the barrel relative to the new condition of a barrel that is free of deficiencies or defects. In some cases a single item such as seam failure may strongly influence this rating.

The culvert barrel general rating is governed by:

- ratings for structural load carrying elements
- roof rating
- sidewall rating
- circumferential seam rating of 2 or less
- longitudinal seam rating
- corrosion rating of 2 or less

- waterway adequacy rating of 2 or less
- floor rated 3 or less will influence general rating

The culvert barrel general rating is based on measurements of dimensional changes and cracked seams. Inspectors are to refer to Table 13.3 of the BIM Inspection Manual for a description of each rating value.

13.6.15. Effects of Struts on Element and General Ratings

There are many culverts on the Provincial and local road systems that are strutted with either steel or timber struts. While the intent is not to arbitrarily increase the barrel general rating due to the presence of the struts, there are situations where a 1 or 2 rating point increase to the barrel general rating may be justified.

If the following criteria are met, then the inspector has the flexibility to increase the barrel general rating by a maximum of 2 rating points (not to exceed a barrel general rating of 4) without increasing the element rating.

13.6.15.1. Criteria for Increasing General Rating

- The inspector must verify the struts have been in place for 2 years or more. This is to ensure that the struts and culvert are stable.
- The struts must be in good condition (i.e. rated as a ‘Special Feature’ at 5 or more).
- The culvert must have at least one permanent reference point for measuring and future monitoring.
- The culvert struts must be inspected after any significant flood event. Ideally, timber struts should be inspected yearly to ensure they are tight and have not been damaged by ice or run-off.
- Consideration should be given to the size of the culvert and to the depth of cover over the culvert. Complete failure of a large diameter culvert under high fills may not be as threatening to public safety as the failure of the same culvert under shallow fill.
- The rating increase would not apply to any culvert with deflections greater than 30%, or with cracked seams with less than 25 mm of remaining steel.
- The rating increase is applied to the ‘General Rating’ only. The element ratings (i.e. seams, barrel, roof, etc) would not change.

The inspector should add a note in the ‘Explanation of Condition’ that the general rating was increased under these provisions.

RTG	COMMENTARY	SHAPE	LONGITUNDINAL SEAM	CORROSION	INFILTRATION	ABRASION
9	New condition					
8	Almost new condition. No repairs required in foreseeable future	No visible signs of defects, distortion, or deformation.	No cracks or defects in seams.	No corrosion.	No infiltration.	No abrasion.
7	Good condition. No action required.	Horizontal and vertical dimensional changes are within 5% of the design dimensions.	No cracks or defects in seams.	No corrosion.	No infiltration.	No abrasion.
6	Generally good condition.	Horizontal and vertical dimensional changes within 5% of design dimensions.	No cracks or defects in seams.	Minor superficial rust but no pitting.	No infiltration.	No abrasion.
5	Adequate. No loss in structural strength.	Horizontal and vertical dimensional changes within 7% of the design dimensions.	No cracks in longitudinal seams, no buckled corrugations in sidewall or roof corrugations.	Some superficial rust but no pitting.	No infiltration.	Abrasion of floor, coating worn off.
4	Low priority for repair.	Horizontal and vertical dimensional changes are within 10% of the design dimensions.	Minor cracks in a single longitudinal seam but can still transmit load.	Extensive corrosion and pitting in roof and/or sidewalls, isolated perforations in floor.	No infiltration but fill material is exposed.	Abrasion of floor, some section loss, isolated perforations.
3	Reduced structural strength. Need for replacement, repair, and/or signing.	Horizontal or vertical dimensional changes are within 10% to 15% of the design dimensions.	Less than 100 mm of steel left between cracked bolt holes along the same longitudinal seam.	Isolated perforations in roof and/or sidewall, extensive perforations in floor.	Minor infiltration of backfill through defects.	Extensive perforations in floor.
2	High priority for replacement, repair, and/or signing. Requires continued observation.	Horizontal or vertical dimensional changes exceeding 15% of the design dimensions. Extreme flattening of roof, inward movement of sidewalls, reverse curvature.	Less than 50 mm of steel left between cracked bolt holes along the same longitudinal seam, 2 or more seams with defects in the same barrel section.	Extensive perforations in roof and/or sidewall, severe perforations in floor.	Void behind culvert from loss of material due to infiltration.	Severe perforations in floor.
1	Immediate action. Danger of collapse.	Reverse curvature in flat horizontal ellipse or round culvert under low fill. Any evidence of impending collapse.	2 or more longitudinal seams with severe cracks in the same barrel section.	Severe perforations in roof and/or sidewall.	Major loss of backfill material due to infiltration.	Continuous perforation due to abrasion.
N	Barrel cannot be accessed for proper inspection.					

Table 13.3 - Rating Guide for Flexible Culvert

13.7. CHANNEL SECTION

This section evaluates the portion of the channel reach, upstream and downstream of the culvert that affects the alignment of the flow and/or threatens the stability of the culvert and the areas surrounding the culvert. Under certain circumstances, the stream flow can cause culvert failure by piping through the fill, erosion of the embankment due to over topping, or scour at the ends. In order to minimize the effects of the channel, it is desirable to align the longitudinal axis of the culvert with the general direction of the stream flow. This situation is achieved, in many cases, by stream diversions which are designed to closely match the geometric characteristics of the natural stream and to minimize erosion.

Sometimes culverts act as channel control structures and force the channel into adjustments such as bank migration, streambed aggradation or degradation, scour, and flow re-alignment. These adjustments can be aggravated by channel constrictions, debris accumulation, presence of beaver dams, diversions, and channel control structures. It is important that the inspector recognizes the impact of these changes in order to provide proper ratings and maintenance recommendations. Any prior knowledge of the stream and the culvert, as well as the land use within the drainage basin would be helpful to the inspector.

In addition to the routine inspection, all culverts should be inspected after a significant flood event.

13.7.1. Channel Alignment

Structure Usage			
Component	Last	Now	Explanation of Condition
Channel (U/S and D/S)			
Alignment			

13.7.1.1. Background

The channel alignment rating is based on the orientation of the longitudinal axis of the culvert with the direction of flow during significant floods. A properly aligned culvert is generally more efficient hydraulically, less susceptible to erosion/scour, and minimizes the severity and frequency of debris accumulation.

13.7.1.2. Inspection and Coding Procedures

- Check for channel migration by looking for erosion at the toe of stream banks, slumping banks, and falling trees.
- Check the transition areas at the end of culverts for erosion/scour and debris accumulation caused by the impingement of the flow.

13.7.1.3. Rating Guidelines

- If the flow is not aligned with the culvert and does not adversely affect the culvert and areas around the culvert, rate 5.
- If the flow is not aligned with the culvert and adversely affects the culvert or the areas around the culvert, rate 4 or less.

13.7.2. Bank Stability

Structure Usage			
Component	Last	Now	Explanation of Condition
Bank Stability			

13.7.2.1. Background

This item evaluates the stability of the channel banks that are located within the reach of channel that affects the flow alignment. Bank stability depends on the characteristics of the channel. The most common problem is slumping, which is usually caused by streambed degradation and/or erosion along the banks.

13.7.2.2. Inspection and Coding Procedures

- Check the locations that are subjected to high velocities, back eddies and impingement by the flow.
- Check the banks that are in the vicinity of beaver dams and debris accumulation.

13.7.2.3. Rating Guidelines

- If bank instability exerts significant control on the channel and operation of the culvert, rate 4 or less.
- If bank instability causes blockage or structural damage to the culvert, rate 2 or less.

13.7.3. High Water Mark

Structure Usage			
Component	Last	Now	Explanation of Condition
HWM (m below top of culvert)			

13.7.3.1. Background

The high water mark (HWM) is a measurement of the highest recorded water level below top of culvert, and may be obtained while the inspector is on site. This measurement is a valuable record used to monitor current conditions and to aid in the design of future replacement structures. HWM are easiest to obtain during or after a significant high water. They are not intended to be a record of normal flow conditions.

13.7.3.2. Inspection and Coding Procedure

- Search the upstream and downstream side of the culvert for evidence of high water marks, debris, ice scars, water stains (see Figure 13.17).
- Interview local residents in the area for high water data, if convenient and time permits.
- Determine if high water marks were affected by ice jams, drift, or backwater conditions.
- Record the elevation of the maximum high water mark relative to the top of culvert. Note the location of the HWM and all other associated comments in 'Explanation of Condition'.
- If there is more than one culvert at a site, the HWM would normally be measured to the top of the primary culvert. The culvert to which the HWM is referenced should be noted in 'Explanation of Condition'.
- If HWM is above top of culvert, record depth as negative and note in 'Explanation of Condition'.
- If no HWM is found and no previous mark is recorded, a comment must be provided indicating "No HWM visible." If a previous HWM is recorded and there is no evidence of a new mark, the previous HWM is retained with the date of the inspection when the information was recorded in the 'Explanation of Condition'.
- Any previous HWMs that were measured above streambed will not appear on the inspection form. If there is a previous HWM recorded, it will have been measured from the top of culvert.

Figure 13.17 - Evidence of HWM

13.7.4. Drift

Structure Usage				
Component		Last	Now	Explanation of Condition
Drift (Y/N)				

13.7.4.1. Background

For the purpose of this manual, drift is defined as wooden material transported by the stream. It includes uprooted trees and vegetation, small branches, sticks, washed out beaver dams, lumber, and logs. Drift tends to accumulate at the upstream end of the culvert and if not removed may cause serious problems such as scour/erosion, piping, blockage of the culvert opening, flooding, impeding fish passage, and siltation.

13.7.4.2. Inspection and Coding Procedures

- Check both the upstream and downstream side for drift accumulation.
- Determine the severity of the problems with drift in the channel by looking for slumping banks, type of land use, and quantity and size of logs in the channel.
- Drift accumulation that causes serious problems should be noted for removal as soon as possible.
- Record Y if drift in channel and note amount and location of drift accumulation in 'Explanation of Condition'.

13.7.5. Channel Bottom

Structure Usage				
Component		Last	Now	Explanation of Condition
Channel Bottom Degrading/Aggrading				

13.7.5.1. Background

A rating is not required for this item. However, the inspector should determine if the channel bottom, within the reach of the channel that affects the flow alignment, is degrading or aggrading. Degradation is the general lowering of the streambed which eventually results in an outfall of the downstream end of the culvert. Aggradation is the gradual build-up of the streambed which reduces the capacity and efficiency of the culvert.

13.7.5.2. Inspection and Coding Procedures

- Look for evidence of degradation which includes outfall on the downstream end, slumping of the channel banks, and extensive scour/erosion on the downstream side.
- Look for evidence of aggradation, which includes formation of sand or gravel bars, excessive siltation of the culvert invert, and vegetation growth in the stream.
- Note if channel bottom is degrading or aggrading and the possible reason for the occurrence.
- If there is no evidence of degradation or aggradation, record as None.

13.7.6. Beavers

Structure Usage				
Component		Last	Now	Explanation of Condition
Beavers (Y/N)				

13.7.6.1. Background

If there are any signs of beaver activity upstream or downstream of the structure, the inventory Y/N question is answered Y with a description provided in the 'Explanation of Condition'. Beaver dams in or at the ends of culverts are addressed in section 13.5.9.

13.7.6.2. Inspection and Coding Procedures

- Record Y if there is evidence of beaver activities in the channel.

13.7.7. Fish Compensation Measures

Structure Usage			
Component	Last	Now	Explanation of Condition
(Fish Compensation Measure 1 :)			
(Fish Compensation Measure 2 :)			

This is a section of the inspection form for the inspector to record any fish compensation measures at the site. A list of common or typical fish compensation measures is shown below:

Woody Plantings

Shrubs or small trees, often willows, planted in the riprap or adjacent to the streambed.

Root Wads

Tree trunks with the attached root mass; buried in the streambank perpendicular to the stream so that only the root mass protrudes from the bank.

Pike Marshes

Shallow off-channel marshes adjacent to a stream, with both shallow water zones 0.0 m to 1.0 m deep and deep water zones 1.5 m to 2.0 m deep, and planted with aquatic vegetation.

Instream Boulders

Boulders placed individually or in clusters in the streambed so that scour holes will be created along the sides and downstream, or boulders placed in pre-excavated holes

Instream Trees

Large weighted trees, with attached roots and branches, sunk into a deep pool or run.

Rock Weirs

Small rock dams lower in the centre than at the sides to direct the flow towards the centre of the channel, often constructed as a V pointing upstream, and sometimes used with a fish pool immediately downstream.

Fish Pools

Pools excavated in the bottom of a stream, 0.5 m to 2.0 m deep, sometimes lined with rock and sometimes with larger rocks placed in the bottom

Fish compensation measures are not rated but the inspector is to provide comments as required.

13.7.8. Culvert Channel General Rating

The culvert channel general rating is governed by:

- channel alignment rating
- bank stability rating of 4 or less
- significant accumulations of drift

13.8. CULVERT GRADE SEPARATION SECTION

This section replaces the channel section of the culvert form when the culvert is used as a grade separation. The culvert may be a vehicular, pedestrian or railway grade separation or a cattle or wildlife underpass. Culverts are not commonly used for a grade separation of major roadways. However, they are often used for local access roads to farms, golf courses, etc. and for cattle and wildlife underpasses. They are also used for pedestrian underpasses.

13.8.1. Road Alignment

Structure Usage			
Component	Last	Now	Explanation of Condition
Grade Separation			
Road Alignment			

Information for rating road alignment for grade separations is covered in section 10.2 except for culvert surface roughness in the vicinity of the crossing which is considered under Roadway Surface. For railway, pedestrian and animal underpasses rate road alignment X.

13.8.2. Roadway Surface

Structure Usage				
Component		Last	Now	Explanation of Condition
Roadway Surface				
(Type :)				
Icing (Y/N)				

13.8.2.1. Background

The roadway surface is the road or pathway that passes through the culvert. Rating should be done relative to acceptable conditions and functionality and the usage of the underpass (vehicular, pedestrian, animals).

13.8.2.2. Inspection and Coding Procedures

- Record or verify the roadway surface type as either Asphalt, Concrete, Gravel or Soil.
- Look for cracks, heaves and uneven surfaces in the vicinity of the underpass that may cause unusual vertical movement of high load vehicles.
- Look for defects in roadway surface that may be a hazard to the traffic using the underpass.
- Look for any evidence of conditions that might cause icing on the underpass surface. If there is evidence of icing record Y and note problem in 'Explanation of Condition'.

13.8.2.3. Rating Guideline

- For railway underpasses rate roadway surface, X.
- If roadway surface meets acceptable condition and functionality and does not cause hazards to structure or user, rate 5 or more.

13.8.3. Traffic Safety Features

Structure Usage				
Component		Last	Now	Explanation of Condition
Traffic Safety Features				
Type				

For details on rating traffic safety features see section 10.3.

13.8.4. Lighting

Structure Usage				
Component		Last	Now	Explanation of Condition
Lighting				

13.8.4.1. Background

Because the opening of a culvert grade separation is generally less than for a bridge it is often necessary to provide lighting in culvert grade separations.

13.8.4.2. Inspection and Coding Procedures

- Check light fixtures for broken bulbs and lens.
- Check wiring for light fixtures for loose or improper connections to structure.
- Note any hanging wires or other defects than may cause a hazard.

13.8.4.3. Rating Guidelines

- If no lighting exists, rate X.
- If no lighting exists but in the opinion of the inspector it is required, rate X and record comments in ‘Explanation of Condition’ and provide a maintenance recommendation.
- If there is minor damage to lighting which does not affect its operation or functionality, rate 5.
- If there are defects which affect the lighting’s operation or functionality, rate 4 or less.

13.8.5. Drainage/Barrel Leakage

Structure Usage				
Component		Last	Now	Explanation of Condition
Drainage				
Barrel Leakage (Y/N)				

13.8.5.1. Background

For the purpose of this section drainage refers to the disposal of water that reaches culvert roadway surface. Often the roadway surface of a culvert grade separation will be low relative to the surrounding ground surface and drainage can be a problem.

13.8.5.2. Inspection and Coding Procedures

- Look for signs of ponding in culvert.
- Determine if any existing gutters or other water disposal systems are clogged or not functioning.
- Look for any damage to structure or embankment caused by roadway drainage.
- Record Y if there is any barrel leakage and provide comments in ‘Explanation of Condition’.

13.8.5.3. Rating Guidelines

- If drainage system is functioning and does not contribute to damage to structure or embankment, rate 5 or more.
- If there is ponding in culvert that would cause hazard to traffic, rate 2 or less.

13.8.6. Structure in Use

Structure Usage				
Component		Last	Now	Explanation of Condition
Structure in Use (Y/N)				

In some cases a culvert grade separation may be no longer in use, particularly if it is a cattle underpass. The inspector is to record or verify Y/N in the ‘Structure in Use’ field. If N, provide comments.

13.8.7. Culvert Grade Separation General Rating

The culvert grade separation general rating is governed by:

- road alignment rating
- roadway surface rating
- traffic safety features rating
- drainage rating

13.9. CULVERT INSPECTION / MAINTENANCE SUMMARY

This section deals with the items noted on the last page of the BIM form. This page constitutes a summary of the structural condition of the culvert, its functional capabilities, routine maintenance requirements, and details of the high priority maintenance items. It provides most of the pertinent engineering information required to establish priorities for maintenance, rehabilitation or reconstruction.

A reliable culvert inspection program must be complimented with an effective maintenance operation to ensure identified deficiencies and problems are addressed properly. It is believed that the trained bridge inspector, knowledgeable in routine culvert maintenance, is in the best position to make maintenance recommendations while at the site.

13.9.1. Maintenance Recommendations

Maintenance Recommendations						
Inspector Recommendations	Year	Inspector Comments	Department Comments	Target Year	Est. Cost	Cat.#
SHOTCRETE REPAIRS						
PLACE ADDITIONAL RIP RAP						
REMOVE DRIFT ACCUMULATION						
INSTALL CONCRETE/STEEL LINING						
INSTALL STRUTS						
INSTALL CONCRETE COLLAR/CUTOFF						
REPAIR SEAMS						
OTHER ACTIONS						
OTHER ACTIONS						
OTHER ACTIONS						

Structural Condition Rating (Last/Now) (%)		Sufficiency Rating (Last/Now) (%)		Est. Repl. Yr.		Maint. Reqd. (Y/N)	

13.9.1.1. Background

This section contains a list of typical maintenance recommendations for culverts and space for additional items. The inspector fills in the year that maintenance should be completed together with comments and estimates/quantities (separate sheet if required). After the inspection report is submitted the Department reviewer provides comments, target year and cost estimate if in agreement with recommendations, and assigns a category number to assist in programming the maintenance actions.

13.9.1.2. Guidelines for Maintenance Recommendations for Culverts

- Culvert elements rated 5 or more should not have any maintenance recommendations except for preventative maintenance such as remove drift accumulation.
- Culvert elements rated 3 or less should have a maintenance recommendation with an accompanying photograph.
- Maintenance recommendations can include any of the following: repair, rehabilitation, replacement, assessment, Level 2 inspections, reduced inspection cycle or monitoring.
- The recommendation to ‘monitor’ should be used sparingly. It should be used for items that are measurable and where comparison of changes can be made with clear and readily identifiable reference marks.

- Timing of culvert maintenance recommendation should generally follow the time lines indicated below depending on the element rating and also taking into consideration the routine inspection cycle for the culvert:
  - 4 low priority
  - 3 (structural element) medium priority, repairs and maintenance completed before the next inspection (six months to three years) e.g. barrel sag rated 3, recommend placing struts in next 1 to 2 years
  - 3 (non-structural) repairs may be delayed if defect not impacting life and operation of the structure e.g. culvert coating rated 3
  - 2 high priority, repairs and maintenance completed within six months
  - 1 immediate action
- If there are no maintenance recommendations the inspector records N in the 'Maintenance Required' field. If there are maintenance recommendations, record Y.

13.9.1.3. Estimating Quantities

Where practical and applicable, the inspector is to estimate the material quantities required for recommended repairs and maintenance. These estimated quantities are to be recorded on a separate sheet of paper if the space provided on the inspection form is not adequate and submitted with the inspection form.

Example:

- 3 cu.m of Class 1M rock riprap

13.9.1.4. Recommending Level 2 Inspections

Level 2 inspections are detailed inspections requiring specialized equipment and/or expertise. These inspections gather specific information, measurements and observations not captured on the routine Level 1 inspections. Further information on Level 2 inspections may be found in the Level 2 BIM Inspection Manual. Recommendations for Level 2 inspections can be made by inspectors during the routine Level 1 inspection. The Department will review the recommendations and make arrangements for the Level 2 inspection if it is required.

Municipalities should not undertake any site preparation measures until the Bridge Manager has been contacted and agrees a Level 2 inspection is required.

13.9.1.5. Culvert Barrel Measurement

A Level 2 inspection may be recommended when critical barrel elements such as roof, sidewall or seams are rated 3 or less and/or safety concerns have been identified.

A Level 2 inspection should be recommended when two inspections have been completed without a proper and thorough inspection of all culvert barrel elements. Water levels may prevent access to the barrel section and consequently critical elements are rated N. In some situations, scheduling a Level 1 inspection during low flow conditions may allow for a thorough inspection.

Culvert barrels that are inaccessible throughout the year should be flagged and recommended for a Level 2 inspection if two inspections have been completed without proper access to the barrel section.

13.9.2. Estimated Replacement Year

The estimated replacement year is the inspector's subjective estimate, at the time of the inspection, of when the structure will need to be replaced assuming normal routine maintenance is carried out without including the effects of possible major rehabilitation. This estimate should be based on factors such as structural condition, culvert capacity, horizontal and vertical alignments, traffic volumes, age, etc.

Life expectancy table for each culvert type is provided below to help with this estimation.

The values in the table are averages only and the inspector must apply judgment based on the actual condition of the structure. The table is separated into three categories for low, average and high life expectancy.

LIFE EXPECTANCY TABLE FOR CULVERTS			
TYPE	**LIFE EXPECTANCY (YEARS)**		
	Low	**Average**	**High**
Concrete	40	60	80
Corrugated Steel	25	45	60
Timber and Others	20	35	60
Considerations: ▪ deformation and cracking (quality installation) ▪ corrosive or chemically aggressive environment ▪ abrasive bed load ▪ favorable decay conditions, preservative treatment			

Table 13.4 - Life Expectancy Table for Culverts

As stated earlier, the estimated replacement year assumes that all required routine maintenance is carried out. Routine maintenance is maintenance and repair actions that do not have enough impact on the culvert to extend the life of the culvert (e.g. remove drift, place rip-rap, install struts).

13.9.3. Special Comments for Next Inspection

Special Comments for Next Inspection		Department Comments	

The bridge inspector may use this space to record comments that would be useful for the next inspection. If monitoring is recommended record measurements and/or note reference points for next inspection. Do not list maintenance items in this space since the field does not permit sorting of data.

The ‘Department Comments’ field allows the Department reviewer to make notes, comments or recommendations.

13.9.4. Maintenance/Rehabilitation Strategy

Maintenance Reviewed By		Date		Estimated Total	
Proposed Long-Term Strategy					
On 3-Year Program (Y/N)					
Proposed Action					
Previous Inspector's Name		Previous Assistant's Name			
		Previous Inspection Date			

This section of the form is filled out by the Department reviewer. Details on the information in this section can be found in section 11.5.

13.9.5. Next Inspection Date/Inspection Cycle

Next Inspection Date	
Inspection Cycle (months)	
Comment	

The next inspection date is system generated based on the last inspection date and the appropriate inspection cycle or is manually changed by the Department reviewer. The cycle may be the normal default cycle for the type of bridge and class of roadway (see section 2.5) or may be modified by the Department reviewer as noted in the 'Comment' field. If the inspector feels that a shorter inspection cycle than the default cycle is required, the shorter inspection cycle should be noted in the 'Special Comments for Next Inspection' field together with comments justifying the recommendation for modified cycle. The inspector can only recommend a shorter cycle. The inspector cannot recommend a longer inspection cycle than the default cycle.

14. CHAPTER 14 – CULVERT STRUCTURAL CONDITION AND SUFFICIENCY RATINGS

14.1. STRUCTURAL CONDITION RATING

The structural condition rating is the ratio of the general rating for the culvert barrel to the maximum possible rating and is expressed as a percentage. It reflects the structural condition of the culvert barrel at the time of the last inspection compared to the structural condition of a new culvert barrel without any defects.

Where two or more bridge size culverts exist, the structural condition rating reflects the structural condition of the worst barrel.

14.2. SUFFICIENCY RATING

14.2.1. Background

The culvert sufficiency rating is a computerized procedure that is undertaken automatically by the BIM system module to produce a single numerical value in terms of a percentage using three major impact categories to represent the present condition, level of service, safety of a culvert and its approach roads, relative to that of a new culvert at the same location. This rating is calculated by applying a set of mathematical formulas to the inspection and inventory data after each inspection, and is printed on the last page of the BIM form. The rating ranges from 0% to 100%, with a lower rating indicative of a higher priority for replacement, rehabilitation, or maintenance. A numerical value of 100% is representative of a culvert that is in excellent condition and provides the best possible level of service at its present location.

14.2.2. Sufficiency Rating Uses

The culvert sufficiency rating is intended to be used with other related criteria to:

1. Provide a rational basis to facilitate management functions including priority planning for replacement, rehabilitation, and maintenance.
2. Evaluate the adequacy of culverts in their present condition to adequately serve public needs on a regional or provincial basis.
3. Provide data that can be used to evaluate the present cost of replacement or rehabilitation in order to achieve an acceptable level of service.

It should be recognized that the sufficiency rating should not be used as the only basis for management decisions since it does not include any cost/benefit factor, economic factor, social, or environmental factor; nor does it identify alternatives, optimal solutions, timing, or budgetary constraints, etc.

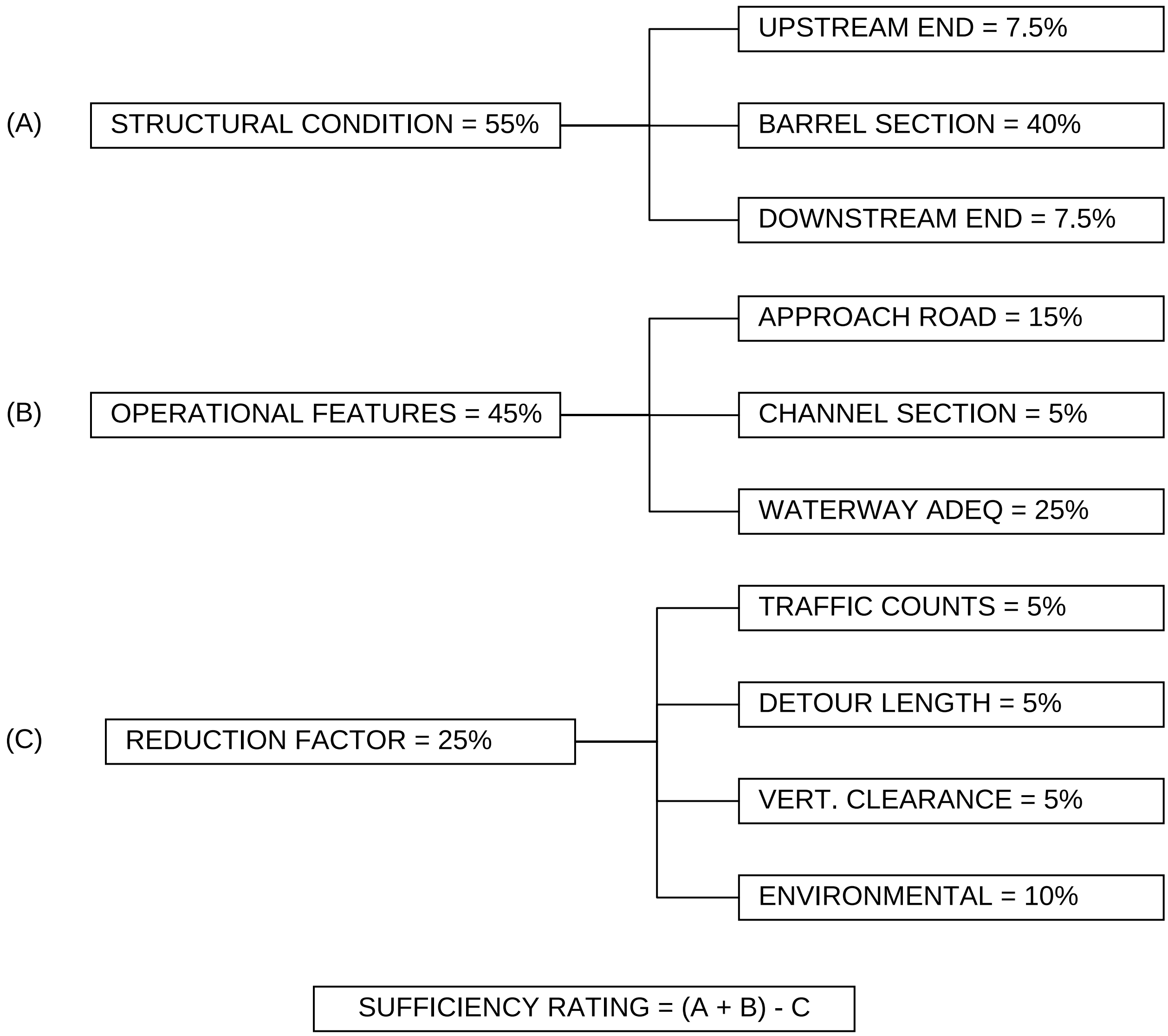


Figure 14.1 - Sufficiency Rating Components

14.2.3. Sufficiency Rating Components

The general outline of the sufficiency rating is shown on Figure 14.1. The rating system uses data from the BIM system and other TIMS system modules. Once the inspection data is keyed into the computer, the sufficiency rating is calculated automatically using a series of pre-determined formulas. Thus, the sufficiency rating is a by-product resulting from the use of existing inspection and inventory data.

The culvert sufficiency rating considers three major impact categories which are weighted in accordance with their relative importance. These are structural condition (55%), operational features (45%), and a reduction factor (up to 25%) which is included as an adjustment to reflect the influence of traffic volumes, detour lengths, environmental constraints, and vertical clearance restrictions for culverts used as vehicular grade separations. Each impact category is further divided into elements which are also weighted to indicate their relative importance.

A fraction of the total allocated points for each element is calculated as shown below.

14.2.3.1. (A) Structural Condition:

This category consists of three elements: upstream end (7.5%), barrel section (40%), and downstream end (7.5%). The distribution of the allocated points is directly related to the general condition rating (GR) for each element, and as such the general rating must be noted on the BIM forms.

For Upstream End:	A1 = 0.938 x (GR - 1) %
For Barrel Section:	A2 = 5.000 x (GR - 1) %
For Downstream End:	A3 = 0.938 x (GR - 1) %

14.2.3.2. (B) Operational Features:

This category consists of three elements: approach road (15%), channel section (5%), and waterway adequacy (25%).

The sufficiency rating of the culvert approaches is related to the general rating which must be noted on the BIM form by the bridge inspector after considering:

a) the existing vertical and horizontal alignments
b) embankment stability

A vertical or horizontal alignment that can be driven at the legal or posted speed limit of the road is rated 5 or more.

For Approach Roads:	B1 = 1.875 x (GR - 1)%

Note: GR = 9 when the approach road general rating is greater than or equal to 5.

The sufficiency rating of the channel depends on the general rating of the channel noted on the BIM form. The general rating considers channel alignment, bank stability, and the presence or absence of drift and beavers. The general rating must be provided on the BIM forms.

For Channel Section:	B2 = 0.625 x (GR - 1)%

Waterway adequacy is defined as the capability of the culvert to pass the design discharge without causing flooding over the embankment and/or areas upstream of the culvert.

The sufficiency rating is dependent on the rating noted for the waterway adequacy on the BIM form. This rating must be provided on the BIM forms.

For Waterway Adequacy: B3 = 3.125 x (WA - 1)%

14.2.3.3. (C) Reduction Factor:

This category consists of AADT (5%), Detour Length (5%), Vertical Clearance (5%), and Environmental Considerations (10%). This reduction factor is applied to the sum of categories A and B in a manner that reflects the impact of these elements on the importance and operation of the culvert.

AADT:

For Provincial Highways the AADT is automatically placed on the BIM form.

The default values used when the AADT is not available are:

Local Roads = 70 vpd
Provincial Highways (1-216, 900+) = 300 vpd per lane
Provincial Highways (500-899) = 150 vpd

The reduction factor for AADT is the lesser value of either C1 or C2, obtained by the following formulas:

For AADT: C1 = (((AADT - 25)/ 36) exp. 0.28) - 0.5 %

Where, C1 = 0 for AADT equal to or less than 25.
C1 = 5 for AADT equal to or greater than 15000.
AADT is for 2-lane roads only. For 4-lane and 6-lane roads, the AADT is divided by 2 and 3 respectively.

OR

For AADT: C2 = 0.10 x (100 - (A+B))%

Where, C2 = 0 when (A+B) is equal to 100
C2 = 5 when (A+B) is equal to or less than 50

Example: If the AADT = 4000, and (A+B) = 80
Then C1 = 3.23, and C2 = 2.0 (governs)
Therefore, the reduction factor for AADT = 2.0

Detour Length:

The detour length is defined as the extra distance to be traveled if the bridge structure on the intended route is removed. In general, the detour structure is the nearest bridge/culvert on the same stream that has about the same allowable load, or one that can be temporarily strengthened on short notice. This factor places a higher priority for replacing a culvert with a longer detour and higher traffic volume than the same culvert with either a shorter detour and/or lower traffic volume.

The default values used when the detour length is not available are:

Local Roads = 75 km
Provincial Highways (1-216, 900+) = 8 km for two lanes, and reduced by 1 km for each extra lane.
Provincial Highways (1-216, 900+) = 40 km.

The reduction factor for Detour Length is the lesser value of either C3 or C4, obtained by the following formulas:

For Detour: C3 = (AADT) x (Detour Length) / 6000 %

Detour Length is in kilometres.

OR

For Detour: C4 = 0.10 x (100 - (A+B)) %

Where, C4 = 0 when (A+B) is equal to 100
C4 = 5 when (A+B) is equal to or less than 50

Example: If the AADT = 1500, the Detour Length is 13 km, and (A+B) = 55
Then C3 = 3.25 (governs), and C4 = 4.5
Therefore, the reduction factor for Detour Length is 3.25

Vertical Clearances:

This element only applies to culverts that are used as vehicular grade separations with vertical clearance of 5.3 m or less. Vehicular grade separations with vertical clearances below the legal limit of 4.15 m are given the full reduction of 5%. Culverts without vertical clearance restrictions, stock passes, pedestrian underpasses, or grade separation with vertical clearances of more than 5.3 m are given zero points. For culverts with more than one vertical clearance postings, the program uses the minimum value.

For Vertical Clearance: C5 = 4.348 x (5.3 - VC) %

Where, VC is the measured minimum vertical clearance if available or else the minimum theoretical value from BIS.

Environmental Considerations:

This element contributes 10% to the reduction factor. It is based on the rating of 'Fish Passage Adequacy'. Culverts that are not on fish-bearing streams do not contribute to the reduction under this element.

For Environmental: $C6 = 10 - (1.25 \times (GR - 1))\ \%$

Note: GR = 9 when the fish passage adequacy is rated 5 or more or X.
GR = 1 when the fish passage adequacy is rated 2 or 1.

14.2.4. Sample Calculation-Sufficiency Rating

The following information was extracted manually from a BIM report:

Upstream end general rating = 6
Barrel general rating = 5
Downstream end general rating = 4
Approach roads/embankment general rating = 4
Channel general rating = 6
Waterway adequacy rating = 3
Fish passage adequacy rating = 8
Road is RLU 208G-090
Roadway width = 7.6m
No guardrail installed
Design loading is HS 20
AADT not recorded
Detour length = not available

Step 1 Structural Condition (A):

For Upstream End:	A1 = 0.938 x (6 - 1) = 4.69%
For Barrel:	A2 = 5.000 x (5 - 1) = 20.0%
For Downstream End:	A3 = 0.938 x (4 - 1) = 2.81%
	Thus, A = 4.69 + 20.0 + 2.81 = 27.5%

Step 2 Operational Features (B):

For Approach Roads:	B1 = 1.875 x (4 - 1) = 5.63%
For Channel Section:	B2 = 0.625 x (6 - 1) = 3.13%
For Waterway Adequacy:	B3 = 3.125 x (3 - 1) = 6.25%
	Thus, B = 5.63 + 3.13 + 6.25= 15.0%

Step 3 Reduction Factor (C):

Since the AADT is not available, use the default value of 70 for local roads.

For AADT: C1 = (((70 - 25)/ 36) exp. 0.28) - 0.5 = 0.6% (governs)
C2 = 0.10 x (100 - (27.5+15)) = 5.8%

Since the detour length is not available, use the default value of 75 km for local roads.

For Detour Length: C3 = (70 x 75) / 6000= 0.88% (governs)
C4 = 0.1(100 - (27.5+15)) = 5.75%

The reduction for vertical clearance is zero (i.e. C5 =0) since the culvert is located on a stream.

Since the fish passage adequacy rating is 5 or more, then GR is equal to 9.

For Environmental Considerations: C6 = 10 - (1.25 x (9 - 1)) = 0%
Thus, C = 0.6 + 0.88 = 1.5%

SUFFICIENCY RATING IS = (27.5 + 15 - 1.5) = 41.0 %

15. CHAPTER 15 – SIGN STRUCTURES

15.1. INTRODUCTION

For the purpose of this manual sign structures are defined as structures that are designed to support a sign or combination of signs with an area greater than 4 m2 which is located over the roadway surface (outside shoulder to outside shoulder). Structures designed to support permanent electronic message boards are considered sign structures. Photos of some typical types of sign structures are shown at the end of this chapter (see Figure 15.1 to Figure 15.3).

There are a number of sign structures located throughout the province, many of which are on provincial highways. They provide information to the traveling public by indicating directions to towns, cities, other highways, etc.

The BIM form used for sign structures is similar to forms used on other structures. The rating system and recording procedures are the same as for all other structures and many areas of the form can be related to specific areas or chapters of the BIM Inspection Manual. For instance, the criteria for approach road ratings for vertical and horizontal alignments is the same as those used for the alignment of bridges as discussed in chapter 6, section 6.2 Horizontal Alignment and section 6.3 Vertical Alignment. Further similarities and comparisons to other chapters of the BIM Inspection Manual will be discussed throughout this chapter.

15.2. NAMING CONVENTION FOR SIGN STRUCTURES

Normally, a sign structure will have the same five-digit file number as the grade separation to which it is associated.

If a sign structure is not associated with a grade separation it will have its own bridge file number.

As noted in section 4.1.1 Bridge File Number, each sign structure will have a bridge file number and a business visual identifier of up to three characters. The identifier is used to describe the sign structure as follows:

- The first character is Z (sign structure).
- The second character is the direction of travel as you approach the sign structure: W (westbound), N (northbound), etc.
- If there is more than one sign structure in the same direction of travel the third character is numeric (1, 2, 3, etc.) identifying each sign structure.

Use the following numbering convention when there is more than one structure in the same direction of travel. Start with the first structure you come to when approaching the grade separation in the traveling direction (e.g. first structure you come to traveling in the westbound lanes is ZW1, next structure is ZW2, etc.).

If a sign structure is added or deleted at a grade separation/intersection, it may result in a change to the visual identifier of an existing sign structure (e.g. If a third sign structure was added in the westbound direction the system would re-number the business visual identifier for the signs using the numbering system noted above. First structure you come to traveling in the westbound lanes is ZW1, next structure is ZW2, etc.).

Sign Structures also have a Steel Plan Index number (A-number). There is normally a plaque attached to the sign structure showing this number. This A-number should be recorded on the BIM inspection forms.

15.3. INVENTORY DATA

This section consists of BIS inventory information and requires verification and updating by the inspector.

Detailed information and guidelines relative to this section can be found in Chapter 4 of the BIM Inspection Manual.

15.4. UTILITIES

Utilities (Located at)			
Telephone		Gas	
Power		Municipal	
Others		Problem (Y/N)	
Remarks			

15.4.1. Background

Utilities are very common on and around sign structures. Some of the structures are equipped with lighting and a power conduit may be attached to at least one of the pedestals.

The owner of the utility is responsible for the inspection, maintenance and operation of that utility. Although the inspector is not required to provide a condition rating, all utilities must be checked to ensure that they:

a) do not interfere with routine maintenance
b) do not create a hazard to the traveling public
c) are properly attached to the structure

15.4.2. Inspection and Coding Procedures

- Note the location of each utility (i.e. 2 wire OH, S. of CL).
- Look for excessive sagging that may cause cracks or leaks, and/or may reduce vertical clearance.
- Look for signs of damage, corrosion, and loose connections on the utility and its supports.
- Look for improper methods of attaching utilities to the structure.
- Note any utility that may interfere with routine maintenance.

- Utilities with any problems which create a hazard to the public or the structure should be recorded on the BIM report and reported as soon as possible to the Bridge Manager.
- Check the utility and its support to ensure they do not affect the structural integrity or aesthetic appearance of the structure.
- The following methods of attachment are not permitted and if present should be noted on the BIM report:
  a) explosive driven attachment to both steel and concrete
  b) welding on or drilling into steel members
  c) any other attachment that creates a hazard or compromises the integrity of the structure

15.5. APPROACH ROAD/SAFETY FEATURES

Approach Road / Safety Features				
		Last	Now	Explanation of Condition
Horizontal Alignment				
Vertical Alignment				
Roadway Width (m)				
Traffic Safety Feature				
Type				
Guardrail (Y/N)				
Guardrail				
Length (m)				
Current Standard (Y/N)				
Termination Type				
Approach Road/Safety Features General Rating				

15.5.1. Horizontal and Vertical Alignment and Roadway Width

The alignment and roadway width elements in this section of the form should be rated in accordance with the guidelines discussed in chapter 6, sections 6.2, 6.3, and 6.4 of the BIM Inspection Manual.

15.5.2. Traffic Safety Features

15.5.2.1. Background

For the purpose of this section, traffic safety features may include, but are not limited to, such devices as delineator boards or markings, medians or parapets, jersey barriers, advanced warning signs, flashing lights, vertical clearance signs and energy attenuators such as the steel drum system. Although guardrail is also considered a safety feature it is rated separately.

15.5.2.2. Inspection and Coding Procedures

- Record the types of traffic safety features that are present on site.
- Check the connections of all traffic safety features.
- The rating should reflect the condition of the safety features and their attachments.

15.5.2.3. Rating Guidelines

- If traffic safety features are not present on site and are not required, rate X
- If traffic safety features are not present and are required, rate X and provide comments and recommendations.

15.5.3. Guardrail

15.5.3.1. Background

Guardrails or other types of railings are generally installed along the outside edge of the road shoulder to provide a safer driving environment and prevent collisions with the support columns.

The element must be given a rating based on condition and functionality. Also, the following inventory information should be checked or noted:

a) length
b) meets current standard (Y/N)
c) type of termination

The current standard for roadside hazards such as sign structure posts is a W-Beam section with the center of the flexbeam mounted 550 mm above road surface with a post spacing of 1905 mm and turndown ends in the direction of traffic. The length of the flexbeam depends on the roadway traffic volume and the distance the hazard is from the roadway. For more details refer to the Department standards for roadway guardrail.

15.5.3.2. Inspection and Coding Procedures

- Record the minimum length of the guardrail to the nearest meter and note its location.
- Record the type of termination (i.e. turndown, bulb ends or others).
- Check all connections at rails and posts.
- Check the condition of the guardrail and posts.

15.5.3.3. Rating Guidelines

- The rating should only reflect the condition and functionality of the guardrail and posts and its ability to function as originally designed. Guardrail systems that do not meet the current standard should not influence this rating.
- Guardrailing that has minor damage but is still functional, rate 5.
- Rail splices with missing bolts or improper laps, rate 4 or less.

- Railing that is damaged and is a potential hazard, rate 3 or less.
- Railing that is too high or too low and affects functionality, rate 4 or less.

15.5.4. Approach Road/Safety Features General Rating

The approach road/safety features general rating is governed by:

- horizontal alignment rating
- vertical alignment rating
- safety concerns with traffic safety features or guardrail

15.6. SUBSTRUCTURE

Substructure			
Bridge Component	Last	Now	Explanation of Condition
Pedestal			
(Total No. :)			
(Type :)			
(Offset from Shoulder (m) :)			
Column			
(Type :)			
Connections			
Coating			
Substructure General Rating			

15.6.1. Background

The substructure is defined as the pedestals, columns, and all supporting connections. These elements are designed to accommodate:

a) the dead load of the overhead sign structure
b) live loads such as wind, vehicle collision and other external forces

15.6.2. Pedestals

15.6.2.1. Background

Pedestals are normally constructed of concrete and provide the base for the column attachment. They are usually located in close proximity to the road shoulder and as such are susceptible to vehicle collision and attack from de-icing salts.

15.6.2.2. Inspection and Coding Procedures

- Record the total number of pedestals on site.
- Identify type of pedestal (i.e. concrete, steel, other).
- Measure and record the offset distance from road shoulder to pedestal to the nearest tenth of a metre.

- Check for scaling or spalling of concrete surfaces or rusting and corrosion of steel surfaces.
- Light scaling of concrete surfaces should not be a reason for lower ratings.
- Check for damage from vehicle or wide load collisions.

15.6.2.3. Rating Guidelines

- If defects are present which reduce the load carrying capacity of the pedestal, rate 3 or less.

15.6.3. Columns

15.6.3.1. Background

Columns are the portion of the sign structure that extends from the overhead sign down to the pedestals. They are generally constructed of steel and as with pedestals, they are open to attack from de-icing salts and chemicals, and are also susceptible to vehicle and wide load collision damage.

15.6.3.2. Inspection and Coding Procedures

- Record the type of column present at the site.
- Check the alignment of columns. Estimate and record any misalignment (bends, bows, kinks) that may be present from collisions, etc.
- Check the surface condition of columns, especially in the splash-zone area. Columns that are rusted but do not show visible pitting or section loss should not be down-rated.
- Check welded stiffeners at the bottom of columns for cracks or other defects.

15.6.3.3. Rating Guidelines

- If extensive corrosion or pitting is present, rate 4 or less.

15.6.4. Connections

15.6.4.1. Background

This portion of the form refers to the attachment between the columns and pedestals, which normally consist of a number of large anchor bolts and nuts. Bearing plates or pads may also be present.

A good connection is essential in ensuring that the sign structure is able to resist the loads exerted on it and transfer these loads down to the pedestals and surrounding ground.

15.6.4.2. Inspection and Coding Procedures

- Check that all anchor bolts and nuts are present and that they appear torqued.
- Check that all bolts are firmly attached or anchored to the pedestal and that all concrete in the area of these connections is sound.
- Check all welds and other connections for cracks or other defects.

15.6.4.3. Rating Guidelines

- Anchor bolts or nuts that show corrosion resulting in loss of section, rate 4 or less.
- Loose or missing bolts or nuts, rate 4 or less.

15.6.5. Coating Substructure

15.6.5.1. Background

This item refers to the coating applied to the columns and the pedestals. Paint is generally applied to steel, while various types of clear and pigmented sealers are used on concrete. The main function of coating systems is to protect the element from deterioration or corrosion, from moisture, salts, chemical, etc.

15.6.5.2. Inspection and Coding Procedures

- Check all areas, especially in splash-zone for rusting, scaling, peeling and other defects common to steel or concrete.
- The rating should include the condition of the paint or coating and its effectiveness to protect the element.
- Check for cracking, peeling and exposure of the structural element or prime coat.
- Look for rust blisters or discoloration.

15.6.5.3. Rating Guidelines

- If top coat is deteriorating but prime coat is intact, rate 5.
- If pitting and/or loss of section is present, rate 4 or less.
- If rusting is present which extends to substrate, rate 4 or less.

15.6.6. Substructure General Rating

The substructure general rating is governed by:

- pedestal rating
- column rating
- connection/bearing rating

15.7. SUPERSTRUCTURE

Superstructure				
Bridge Component		**Last**	**Now**	**Explanation of Condition**
(Sign Type :)				
Special Features				
Special Feature				
(Type :)				
Special Feature				
(Type :)				
Truss Members				
Bottom Chord				
Diagonals				
Verticals				
Connections				
Access Platform				
Coating				
(Type :)				
Touch-Up (Y/N)				
Span Alignment Problems				
Vertical (Y/N)				
Horizontal (Y/N)				
Superstructure General Rating				

15.7.1. Background

For the purpose of this chapter, the superstructure is defined as that portion of the sign structure that is attached to the support columns above the roadway.

For older sign structures the superstructure generally consists of structural steel framework in a truss-like configuration upon which are attached large information signs, lighting, utilities and access platforms. Newer sign structures may consist of tubular frames that either span between or are integral with the support elements.

Inspection of the superstructure would normally be from the ground, using binoculars as required.

15.7.2. Sign Structure Type

The first line of the superstructure section contains inventory information on the type and span length of the sign structure that is extracted from BIS and printed on the form. The inspector should verify that this information is correct. For a specific list of sign types see BIS documentation. Common types of sign structures are:

- Truss type superstructure supported by columns on each side of the roadway.
- Tube type superstructure supported by columns on each side of the roadway.
- Cantilever tube type superstructure supported by single column on one side of the roadway.

15.7.3. Special Features

15.7.3.1. Background

Special features are elements unique to a particular structure and cannot be rated under any other element. These elements can be either permanent or temporary. Typical examples are:

- high load indicators
- special lighting (other than the lighting used on the sign board)
- hazard signing or flashers

These features are to be given condition ratings.

15.7.3.2. Inspection and CodingProcedure

- Note the type of special feature and provide a condition rating.
- Check for defects common to the element (i.e. corrosion of steel, spalling of concrete).
- Use the ‘Explanation of Condition’ space to note additional information such as location, dimensions and condition of the element.

15.7.4. Truss Members

15.7.4.1. Background

The truss members, if present, are made up of individual members, which are connected to form a series of adjoining triangles. This is a common structural configuration which is effective in carrying loads. More detailed information relating to trusses can be found in section 7.16 of the BIM Inspection Manual.

For newer sign structures the superstructure may consist of a steel beam that is generally some type of a tubular section. More detailed information relating to steel girders/ beams can be found in section 7.17 of the BIM Inspection Manual.

15.7.4.2. Inspection and Coding Procedures

- Check the alignment of the truss and the individual members. Misalignment may indicate overstress, and may result in deflection or buckling, especially in compression members.
- Check all members for deformation, warping, and loss of section caused by rust, especially horizontal members and connections since they are more susceptible to debris accumulation and poor drainage.
- Examine lower truss members or lower portion of steel tubular beam for high load damage. Note the location and extent of damage in ‘Explanation of Condition’.
- Check tension members and their connections for fatigue cracks.
- Check compression members for kinks or bows.
- Check for missing or rusted rivets, bolts, and nuts. Look for signs of cracked paint which may indicate deformation or tearing. Examine welded connections for cracks.
- Check for lack of movement (frozen) at pinned joints. Main members which require careful inspection are the entire top and bottom chords, diagonals, verticals, and panel points.
- Poor paint condition should not influence the rating.
- The superstructure section of the form has the section for truss members where you rate Bottom Chords, Diagonals, Verticals, Connections and Access Platform. For tubular frame type structures, rate under ‘Bottom Chord’. All the other elements would be rated ‘X’.

15.7.4.3. Rating Guidelines

- Pitting or scaling of metal or other loss of section caused by corrosion, rate 4 or less.
- Any other defect that would affect the load carrying capacity of the member, rate 4 or less.

15.7.5. Access Platform

15.7.5.1. Background

An access platform and handrail may be attached to the front side of the sign structure. This provides access for light changes, sign changes, and other routine maintenance of the structure. When not in use the handrail is laid flat on the platform so as not to obstruct the visibility of the signs.

It should be noted that this platform is not intended for use by the inspector during the Level 1 inspection. The inspector should view all elements of the structure from the ground using binoculars or other equipment.

15.7.5.2. Inspection and Coding Procedures

- Check for the presence of an access platform. Ensure handrails are laid flat so as not to interfere with sign visibility.
- Check all connections for missing or rusted nuts, bolts, pins, rivets, or other fasteners.
- Check for high load or other damage. Note and record the location and extent of damage in 'Explanation of Condition'.

15.7.6. Coating Superstructure

15.7.6.1. Background

As noted in section 15.6.5 Coating Substructure, the main function of the coating is to provide protection to the element from deterioration or corrosion. The rating in this section applies to the coating found on superstructure members and on the access platform.

15.7.6.2. Inspection and Coding Procedures

- Refer to section 15.6.5 Coating Substructure for detailed inspection procedures.

15.7.7. Span Alignment Problems

15.7.7.1. Background

Most misalignments are indicators of distress in the superstructure, substructure or both.

15.7.7.2. Inspection and Coding Procedures

- Look along top and bottom chords of trusses for sags, bows, buckling, twisting or other signs of distress.
- Check that the truss/beam is mounted level between columns.
- Check for proper positioning and alignment of columns which might affect the alignment of the superstructure.
- Record all alignment problems along with their location and possible causes. A rating is not required.

15.7.8. Superstructure General Rating

The superstructure general rating is governed by:

- load carrying elements in the superstructure
- any safety concerns related to any item on the superstructure

15.8. SIGN

Sign				
Bridge Component		Last	Now	Explanation of Condition
Sign Board				
(Type :)				
Connections				
Coating				
Readable (Y/N)				
Illumination				
Sign General Rating				

15.8.1. Background

This element refers to the information sign or signs that are mounted on the superstructure. Signs are usually made of wood or metal mounted on a steel frame and attached to the superstructure by bolting, welding, pins, hangers, or other methods.

The sign provides directional or other information to the traveling public and as such, should be clean and readable.

Since the sign is generally overhead of traffic and potentially hazardous, it must also be securely attached.

The coating on overhead signs is generally applied to the front side only and is usually a high visibility, reflective coating with lighting or a diamond grade coating without lighting.

15.8.2. Inspection and Coding Procedures

- Check and record the type of sign present at the site.
- Check the sign for damage occurring from collisions, wind or other sources.
- Check all connections, fasteners, hangers, etc., for secure attachment.
- Inspect for noise and movement occurring when trucks and other traffic pass under the sign, which might indicate a loose attachment.
- Check the sign coating for marks, scrapes or other damage that might reduce the reflectiveness or make the sign difficult to read.
- Check lighting, if present, looking for broken lenses, loose connections or loose or hanging power attachments.

15.8.3. Rating Guidelines

- If the sign has damage which affects its readability, rate 4 or less.
- Connections with loose or missing bolts, rate 4 or less.
- If coating on surface is damaged and difficult to read, rate 4 or less.
- If there are broken lenses, loose or hanging power attachments, rate illumination 4 or less.

15.8.4. Sign General Rating

The sign general rating is governed by:

- sign board rating
- connections rating
- coating rating
- illumination rating

15.9. SIGN STRUCTURE INSPECTION/MAINTENANCE SUMMARY

This section refers to the last page of the BIM inspection form. Information for this page of the form that is not specifically noted in this section is the same as noted in chapter 11.

15.9.1. Maintenance Recommendations

Maintenance Recommendations						
Inspector Recommendations	Year	Inspector Comments	Department Comments	Target Year	Est. Cost	Cat.#
REPAIR/REPLACE SIGNING						
PATCH/REPAIR ACCESS PLATFORM						
ADJUST/PAINT PEDESTAL BEARING AREA						
REPAINT SUPERSTRUCTURE						
STRAIGHTEN/REPLACE MEMBERS						
WASHING						
OTHER ACTION						
Structural Condition Rating (Last/Now) (%)		Est. Repl. Yr.		Maint. Reqd (Y/N)		

15.9.1.1. Background

This section contains a list of typical maintenance recommendations for sign structures and space for additional items. The inspector fills in the year that the maintenance should be completed together with comments and estimated quantities (separate sheet, if required). After the inspection report is submitted, the Department reviewer provides comments, target year and cost estimate, if in agreement with recommendations, and assigns a category number to assist in programming the maintenance actions. This section also shows the ‘Last Structural Condition Rating’ and a field for ‘Estimated Replacement Year’. There is no sufficiency rating for sign structures.

15.9.1.2. Guidelines for Maintenance Recommendations

- Structure elements rated 5 or more should not have any maintenance recommendations except for preventative maintenance items such as washing, etc.
- Structure elements rated 3 or less should have a maintenance recommendation with an accompanying photograph.
- Maintenance recommendations can include any of the following: replacement, repair, Level 2 inspections, reduced inspection cycle or monitoring.

- The recommendation to 'monitor' should be used sparingly. It should be used for items that are measurable and where comparison of changes can be made with clear and readily identifiable reference marks.
- Timing of bridge maintenance recommendation should generally follow the time-lines indicated below depending on the element rating and also take into consideration the routine inspection cycle for the structure:

  4 low priority

  3 (structural element) medium priority, repairs and maintenance completed before the next inspection (six months to three years) e.g. column rated 3, fix within a year

  3 (non-structural) repairs may be delayed if defect not impacting life and operation of the structure e.g. superstructure coating rated 3

  2 high priority, repairs and maintenance completed within six months

  1 immediate action
- If there are no maintenance recommendations the inspector records N in the 'Maintenance Required' field. If there are maintenance recommendations, record Y.

15.9.1.3. Estimated Replacement Year

For information on estimating replacement year see section 11.3. There is no specific listing in the life expectancy tables for sign structures, but they should be expected to be similar to 'Rigid Frame/Welded Girder/Deck Truss' type structures.

Figure 15.1 - Truss Type Sign Structure

Figure 15.2 - Tube Type Sign Structure

Figure 15.3 - Cantilever Type Sign Structure

16. ABBREVIATIONS AND GLOSSARY

16.1. ABBREVIATIONS

Standard Abbreviations to be used on BIM report:

abutment	Abut., A1, A2
anchor zone	AZ
cast-in-place	CIP
centreline	CL
cubic meters	cu.m.
deflection	defl.
downstream	D/S
east	E
eastbound lane	EBL
general rating	GR
hazard marker	HM
high water mark	HWM
north	N
northbound lane	NBL
northeast	NE
normal horizontal	NH
northwest	NW
overhead	OH
overhead vertical	OHV
pier one, pier two	P1, P2
right-of-way	ROW
south	S
southbound lane	SBL
southeast	SE
steel girder	SG
span 1, girder 3	SP1G3
square meters	sq.m.
southwest	SW
treated timber	TT
upstream	U/S
west	W
westbound lane	WBL

16.2. GLOSSARY

Abutment	An end support for a bridge superstructure. Abutments are categorized as substructure elements, and are typically constructed of concrete, timber, steel, or from a combination of these materials.
Aggradation	A general and progressive buildup or raising of the longitudinal profile of the channel bed as a result of sediment deposition.
Anchor Pile	Used to help prevent high backwall abutments from moving inwards. Driven into firm ground and connected to abutment piles with galvanized steel wires or steel rods.
Approach Road	A Department term to describe a designated municipal road that connects the adjacent town, village or summer village to the Provincial Highway System.
Approach Slab	A flat slab that provides a smooth transition from the approach roadway to a bridge with one end supported on the bridge and the other floating on the approach fill.
Backwall	That part of the bridge abutment above the bearing seats, used primarily to retain approach fill and to provide support for an approach slab and deck joint assembly.
Backwall Scab	A vertical timber member behind the backwall sheeting, in line and connected to the timber piles by means of a steel strap and bolts. The purpose of the scab is to help prevent the timber abutment cap from rotating.
Backwater	The rise in water level caused by a downstream obstruction or constriction in a channel.
Batter Pile	A pile driven at an angle inclined to the vertical to provide higher resistance to lateral loads.
Batter Post	The end portion of a truss that carries the compression forces of the top chord down to the bearing.
Beam	A structural member whose primary function is to transmit loads to the support primarily through flexure and shear. A beam may be supported at the ends and/or at intermediate locations.

Bearing	A structural device that transmits loads (from the superstructure to the substructure) while facilitating translation and/or rotation. Typically bearings are either of the sliding or fixed type and are categorized as superstructure elements. See also Neoprene.
Bearing Pile	A pile whose purpose is to carry axial load through friction or point bearing. Frictional support is provided by the soil surrounding the pile and end bearing support by the underlying rock or other very firm material.
Bearing Seat	The top surface of a cap or a corbel that receives loads from the bearing.
Bent	A type of pier consisting of two or more columns or column-like components that are connected at their top ends by a cap, strut, or other component holding them in their correct positions.
Beveled End	The end portion of a culvert that is cut or formed to lie in a plane inclined to the vertical. The beveled end extends the invert beyond the barrel, and helps facilitate a smooth transition between the roadway sideslopes and the natural banks of the watercourse, etc. A beveled end also improves the hydraulic characteristics of a culvert.
Box Culvert	A closed invert culvert having a monolithic rectangular (or trapezoidal) cross-sectional shape. Box culverts are typically constructed with concrete (either precast or cast-in-place).
Breast Wall	The portion of a bridge abutment located below the bridge seat and between the wing walls. Essentially, a breast wall is a component of a high abutment and is employed to retain the lower portion of the approach fill to the bridge (a backwall being used to retain the upper portion of the approach fill).
Bridge Approach	The section of road located within 1 kilometre of each end of a bridge or culvert.
Bridge Approach Railing	A roadside guardrail system preceding a bridge structure and attached to the bridgerail system, intended to prevent a vehicle from impacting the end of the bridgerailing or parapet.
Bridge Apron	An area of protective material laid down on a streambed (or canal bed) to control local scour around a feature requiring protection. Typically, riprap is used to provide this protection. See also Riprap.

Bridge Culvert	A structure that is a conduit located below the roadway surface facilitating passage of streams or other traffic through the roadway. Bridge size culverts have an equivalent diameter of at least 1500 mm. See also Beveled End, Concrete End Treatment, CSP, Culvert Barrel, Piping and SPCSP.
Bridgerail	A safety feature attached to a bridge structure to help prevent errant vehicles from going over the edge. See also Parapet.
Bridge Structure	Infrastructure grouping that includes bridges (single-span, continuous beam, single or multiple arch, suspension, frame type, bridge size culverts, watercourse training works and overhead sign structures. See also Major Bridge and Standard Bridge.
Camber	The difference in elevation of the midspan point and a straight line drawn between the two ends. When used in the context of culvert construction it is the adjustment required in the longitudinal profile of the bedding to compensate for post-construction settlement. For bridge structures it refers to upward curvature caused by prestressing or curvature added during fabrication to compensate for dead load deflection or long term creep.
Cap	A horizontal beam located below the abutment or pier bearings and spans between piles. The purpose of the cap is to distribute the dead and live loads from the superstructure. The term can also be used to describe the cover (metal or plastic) used to protect the exposed wood end grain from wetting.
Cathodic Protection	An electrical method of preventing corrosion of one steel component by the sacrificial corrosion of a second component. Operates by electrically connecting the two structures in the same electrolyte. For bridge applications, cathodic protection has been used to protect the soil side of metal culverts and on bridges to protect the steel reinforcement in concrete decks.
Chords	Top and bottom members of trusses (typically steel angles or channels) that run the full length of each simple or continuous span.
Clear Roadway	Total clear width of the traveled lanes. The distance between the inner faces of the curbs, measured perpendicular to the center line of the road to the nearest 0.1 metre. For tapered roadways, the minimum width is used. For structures with medians, total clear width of all the lanes is used.
Collar	See Concrete End Treatment.

Concrete End Treatment	A concrete enhancement component attached compositely around the end(s) of large diameter metal culverts to strengthen the beveled end. Its purpose is to improve hydraulic performance, aesthetics and to help resist uplift forces. A full concrete end treatment is comprised of a cutoff wall, collar, and headwall. The cutoff wall is a transverse vertical wall located at the end of the culvert that starts at the invert and extends below the culvert. (A cutoff wall may also be used at the end of drop structures, spillways, etc.). The collar is a longitudinal stiffening beam which extends along the length of the bevel. The headwall is a transverse vertical wall located over the crown (or roof) of the culvert.
Corbels	A beam spanning between two piles in the direction parallel to the centerline of the bridge.
Corrosion Analysis	The review of corrosion parameters at a site that will affect the life of a structure. Generally conducted at a culvert site to determine the estimated life of a galvanized pipe.
Corrugated Steel Pipe	Galvanized or aluminized sheet steel which is formed into a pipe by a rolling process. This popular culvert material is commonly referred to as "CSP." The current method for production favoured by fabricators is to form helical corrugations with continuous seams either locked or welded. Pipe can also be formed with annular seams with riveted seams, but fabricators have now more or less dropped this practice, probably because of production costs.
Culvert	A curved or rectangular buried conduit for conveyance of water, vehicles, utilities, or pedestrians. See also Box Culvert and Bridge Culvert.
Culvert Barrel	The section of a bridge culvert that is circumferentially enclosed.
Curb	A raised surface beside a roadway, forming a vertical or sloping face that delineates the roadway edge and may also channel water. On bridges, the concrete curb also acts as a safety feature by helping to redirect errant vehicles.
Curtain Wall	An extension of the abutment wingwall along the abutment seat that covers the ends of the girders, the gap between the girder ends and the backwall and the abutment bearing.
Cusping	A discontinuity or sharp break in the curvature of the culvert cross-section. It most often occurs at longitudinal seams and can be caused by incorrect manufacture of the plate sections, improper assembly of the plates or rotation of the plates at the seam due to improper torquing of bolts and/or improper backfill.

Cutoff Wall	See Concrete End Treatment.
Dead Load	The load from material that is supported by the (bridge) structure and is not subject to movement.
Debonding	A separation between two layers of material generally caused by improper preparation of the surfaces between the two materials (e.g. debonding between asphalt and concrete deck, debonding between concrete overlay and concrete deck).
Debris	Material transported by the stream or abandoned bridge materials such as piling.
Deck	A component of a bridge superstructure (with or without wearing surface) that carries and distributes wheel loads. See also Wearing Surface.
Deck Joint	A structural discontinuity between two (bridge) components that permits relative rotation or translation between the two, where at least one of the components is the deck. Essentially, these joints in the roadway surface are used to accommodate horizontal movements of the deck that occur as a result of thermal variations or rotations due to traffic loads. Standard drawings for typical joints are available.
Deck Top	The surface on which the wearing surface is bonded. If no wearing surface exists the deck top is in direct contact with the wheels of the vehicle.
Degradation	A general and progressive lowering of the longitudinal profile of the channel bed (i.e. streambed of a watercourse) as a result of long-term erosion.
Delamination	A crack/separation in concrete generally at the surface of a reinforcing layer caused by the corrosion of the steel.
Depth of Scour	The depth of material removed from a streambed by scour, measured below the original bed. See also Erosion and Scour.
Diaphragm	A transverse flexural component connecting adjacent longitudinal flexural components.
Dowel	A relatively short length of round metal bar (sometimes referred to as a pin) used to interconnect or attach two components in a manner to minimize (or limit) movement and displacement.

Drift	Debris, typically trees, woody material, and other trash, which may be transported by a flowing stream. A major flood event can result in large accumulations of drift occurring at bridge sites on "drift-prone" streams.
Drift Pin	A steel pin used (in bridge construction) to connect wood members.
Erosion	The general removal of material caused by the action of flowing water. Erosion may be on stream banks, drainage ditches or any surface that has water flowing over it.
Fish Baffles	An obstruction located in the water flow to slow the velocities to within acceptable limits for the successful passage of fish.
Flange	The wider horizontal sections of a bridge girder found at the top and bottom of the web.
Flex Beam	A galvanized metal guardrail that has a "W" shaped cross-section.
Floor Beam	A transverse beam spanning between longitudinal girders, trusses or arches. Typically this beam carries a bridge deck and/or stringers and is connected to the main load carrying members.
Freeboard	The vertical distance between the level of the water surface normally corresponding to the design flow and a selected reference point such as the bottom of the superstructure, the top of the culvert crown, or the top of the berm.
Girder	A main structural bridge component whose primary function is to resist loads in flexure and shear. Generally, this term is used for fabricated sections. Typically this component supports the bridge deck, floor beams and/or stringers. See also Flange.
Grade Separation	A crossing of two highways or a highway and a railroad, at different levels.
Guidebank	An extension of the bridge headslope or dyke (more or less parallel to a stream) that is designed to direct the stream flow through the area of the bridge opening. Typically the purpose of the guide bank is to help protect a bridge abutment and/or road from erosion.
Hanger	Slender (vertical) bridge member that carries load in tension.
Hazard Marker	Warning signs at a bridge approach, used to delineate the end of the curb and bridgerail. Yellow board with black diagonal lines sloping towards the road.

Headwall	A transverse wall at the end of a culvert. See also Concrete End Treatment.
Height of Cover	Vertical distance between the roadway surface and the crown of a culvert.
Height of Fill	Vertical distance between the roadway surface and the centerline invert of a culvert.
Horizontal Alignment	The configuration of a road or roadway as seen in plan, consisting of tangents, lengths of circular curve, and lengths of spiral or transition curves.
Live Load	A load imposed by vehicles, pedestrians, equipment, wind, ice or components that are subject to movement.
Local Scour	Scour in a channel or on a floodplain that is localized at a pier, abutment, or other obstruction to flow.
Low Level Crossing	Bridge crossing at which it is considered acceptable for flood waters to flow over the roadway. Use of roadway is lost for short periods of time during these flood events.
Major Bridge	A bridge that does not fit the standard bridge category due to the length and height requirements for the bridge or other site conditions. Truss bridges, steel girder bridges and longer span concrete bridges are examples. See also Standard Bridge.
Neoprene	A synthetic rubber that is used in bridge bearings and joints. It is available in various grades to accommodate design requirements. It is a durable material, resistant to oil, water and ultraviolet light.
Parapet	A reinforced concrete wall along the edge of a bridge deck that acts as a bridgerail system.
Pier	A substructure element used to transfer superstructure loads from the spans it supports to the foundation. See also Bent, Pier Cap, Pier Shaft and Pile Bent.
Pier Cap	The top element of a bridge pier, located between the bearing and the shaft or columns. See also Cap.
Pier Shaft	The vertical element of a bridge pier that extends from the bottom of the cap down to the footing or foundation piling.

Pile	A relatively slender deep foundation unit, wholly or partly embedded in the ground, that is installed by driving, drilling, auguring, jetting, or otherwise and that derives its capacity from the surrounding soil and/or from the soil or rock strata below its tip. See also Batter Pile and Bearing Pile.
Pile Bent	A single line of free-standing piles, suitably braced and connected to form a pier. See also Bent.
Piping	A movement of water through the soil around a structure that may cause the loss of fine particles. Piping around a culvert is usually the result of inadequate clay seals and/or a blockage of the culvert causing a hydraulic head at the upstream end. If left unchecked, piping will most likely lead to severe structural problems with the culvert and ultimately to its failure.
Precast Prestressed Concrete Girders	Factory manufactured precast concrete girders strengthened with high-strength steel strand under tension. This tension force keeps concrete in a constant state of compression. Prestressed girders are designed not to crack.
Precast Reinforced Concrete Girders	Factory manufactured precast reinforced concrete girders (sometimes referred to as precast girders). These girders employ reinforcing bars to handle the tension stresses that develop when the girder is in use. It is part of the design assumption that a certain amount of micro-cracking will occur when the girder is in service. See also Reinforced Concrete and Reinforcement.
Reinforced Concrete	Structural concrete containing no less than the minimum amounts of steel prestressing strand or non-prestressed reinforcement. See also Reinforcement.
Reinforcement	Steel reinforcing bars and/or prestressing strand.
Remaining Life	A subjective estimate of how long an infrastructure component (road, bridge or appurtenance) should remain in service without including the effects of possible rehabilitation. This estimate is based on factors such as structural and loading conditions, horizontal and vertical alignments, traffic volumes, age, etc.
Reverse Curvature	The situation/condition that exists in a culvert when the culvert plates have deformed to the point where the curvature on the plate is reversed from its design shape.

Riprap	A hard durable material that is used to provide protection from erosion and/or scour due to moving water. For bridge applications, material such as rock or concrete may be placed along streambanks, headslopes, inlet and outlet of culverts, etc. For road applications, materials such as sandbags or small rocks may be placed in ditches and drainage structures, etc. See also Guidebank and Spur.
Scaling	Deterioration of the concrete surface. Under certain conditions the hardened sand/cement paste which forms the smooth surface layer of the concrete breaks down over time and falls away in 'scaly patches'. Typically the depth of the patches is not deep but generally the coarse aggregate of the interior is exposed.
Scour	The removal of material from a streambed caused by the increase in the velocity of the water at constrictions or obstructions in the water course.
Shear	The force on a component (or element) which tends to deform (or fail) it by sliding the constituent fibres (or molecules) over one another. The application of this force results in internal stresses (shear stresses) developing. All solid materials have an inherent strength to resist these forces. This resistance is referred to as its shear resistance. When the shear stresses due to the applied force are greater than the shear resistance, the material ruptures and shear failure is said to have occurred.
Shear Key	A preformed hollow in the side of a precast component filled with grout or a system of match-cast depressions and protrusions in the face of segments that is intended to provide shear continuity between components.
Sheathing	See Sheeting.
Sheeting	Timber planks (sometimes called sheathing) spiked and bolted to pier or backwall piles and cap to form a wall. Used as an alternative to sway bracing on piers and to retain road fill on abutment backwalls.
Shotcrete	Sprayed in place concrete – more commonly used for repairs at bridges and culverts.
Sight Distance	From any given point, the unobstructed distance a driver can see, usually along the roadway ahead.

Sign Structure	A permanent structure designed and constructed to support a large traffic sign or combination of signs with an area greater than 4m2 which is located over the roadway surface (outside shoulder to out-side shoulder). A structure supporting an electronic message board is also a sign structure. A sign structure is classified as a Bridge.
Siltation	Deposition of solid particles (sand, silt, small rocks, etc.) by flowing water. Siltation occurs in areas where the velocity of water slows down (i.e. the inside of a stream bend, an increase in stream width, behind a dam etc.).
Skew Angle	Angle between the axis of support relative to a line perpendicular to the longitudinal axis of the bridge (i.e. a 0 skew denotes a rectangu-lar or square bridge). The complement of the acute angle between two centerlines which cross. Skew angles are positive (+) for right hand forward (RHF) skew and negative (-) for left hand forward (LHF) skew.
Snooper	Vehicle equipped with a basket or platform on a hydraulic arm used by bridge inspectors for gaining access to the underside or overhead areas of a bridge for inspection.
Spalling	The breaking or bursting of concrete which usually occurs as a result of the expansion forces that develop when steel reinforcing bars begin to corrode.
Spur	Projections from the stream banks, constructed from fill or timber, designed to re-direct stream flows and/or retard bank erosion.
Standard Bridge	A bridge constructed according to Department standard drawings (plans). These bridges are suited for non-complex site conditions and can be put together very quickly. Timber and short span concrete bridges are examples of standard bridges. See also Major Bridge.
Steel Plate Corrugated Steel Pipe	A corrugated steel culvert constructed from curved plates that are bolted together on site to form the basic culvert structure. The plates are fabricated from flat black plate that is corrugated and punched simultaneously, hot dip galvanized, and finally curved to the required shape. This type of culvert is commonly referred to as a SPCSP culvert.

Stirrup	Steel reinforcing bars that are incorporated into concrete beams or girders to provide additional resistance to shear and/or torsion forces. Typically the bars are bent to form a closed rectangular loop, or interlocking "U's", and are place vertically in the web of the beam. During construction they are also used to support the longitudinal reinforcement. In columns, this type of reinforcement is usually referred to as a link. In this application the links are place horizontally and are also used to provide support to the vertical reinforcing bars during construction.
Streambed	The surface of a natural or modified channel bed. See also Aggradation, Degradation, Siltation, Erosion, Scour and Depth of Scour.
Stringer	A longitudinal element supporting the deck and spanning between floor beams.
Stripdeck	Bridge deck wearing surface consisting of timber planking running parallel to the roadway.
Structural Condition Rating	Calculated in terms of a percentage for the last routine bridge inspection. It is the ratio of the sum of the general ratings to the sum of the maximum possible ratings for the superstructure and substructure only.
Strut	A bridge component that is used to resist compressive forces.
Subdeck	Usually refers to a layer of timber planks located between the timber wearing surface (i.e. strip deck) and stringers or beams on a bridge.
Substructure	That part of a bridge, including abutments and piers, which supports the superstructure.
Sufficiency Rating	A computerized rating generated by BIM to produce a single numerical value (in percentage) to represent the present condition, level of service, and safety of a bridge and its approach roads, relative to the acceptable standard of a new bridge at the same location. Sufficiency rating is not done on sign structures or watercourse training structures.
Superstructure	That part of a bridge that spans water, roadway, railway or other obstruction and is supported by the substructure. Typically the superstructure is comprised of the bearings, girders, deck, bridgerail, etc.
Vertical	A vertical bridge member that connects the top and bottom chords or a truss at each panel point.

Vertical Alignment	The configuration of a road or roadway, as seen in longitudinal section, generally consisting of tangents and parabolic curves. Generally referred to as Highway Profile.
Vertical Clearance	The minimum vertical distance between the finished surface of the road and the soffit (underside) of a bridge. Typically a sign advising this height (in metres) is placed on the side of the bridge girder (or other suitable component) above the location at which the minimum vertical clearance occurs.
Watercourse	A natural or artificial channel that conveys water continuously or intermittently through the year. A watercourse can be a river, lake, stream, creek, etc. Watercourses impact highways relative to bridge structure requirements and bridge structures impact watercourses relative to environmental aspects. See also Low Level Crossing and Streambed.
Wearing Surface	Surface in direct contact with the wheels of vehicles. An overlay or sacrificial layer of a bridge structural deck used to protect the structural deck against wear, road salts, and environmental effects. The overlay may include waterproofing.
Wheel Guard	A curb, constructed with timber or steel, used to guide or redirect an errant vehicle. The wheel guard also helps to protect the bridgerail posts from vehicular damage.
Wingwall	A portion of a bridge abutment located on each side of the backwall/ breastwall that is used to retain the approach fill.