6.5 Engineered Structure Inspections

6.5.1 Types of Inspections

Engineered Structure (retaining walls greater than 1.5 m high, bridges and major culverts) inspections can be broadly categorized into two types: routine condition and close proximity inspections. Consult with the ministry bridge engineer when developing the annual strategy and the contracts for routine condition and close proximity inspections.

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Routine condition inspections

Routine condition inspections involve visual and physical (non-destructive) testing of log stringer, steel, concrete, or glulam bridge components, or major concrete, log, or steel culverts. Ensure that these inspections are completed by qualified Inspectors who have appropriate training and experience in inspecting bridge and major culverts and interpreting the results, with the mandatory knowledge and skills requirements listed under service category T07 Technical Bridge and Major Culvert Condition Inspection (PDF) of the ministry's Engineering Equipment & Services (EES) Directory.

For example, if rot is found in wood components, have the Inspector assess the significance of the rot relative to the structure's integrity, and evaluate whether the structural integrity of the components is at risk, considering the amount of rot, component type and use, and location of the rot in the component being inspected. Have the Inspector determine whether structural deficiencies require evaluation by a professional engineer or can be simply rectified with suitable minor repairs.

Close proximity inspections

Close proximity inspections are generally carried out to review complex, larger structures or where deficiencies have been noted in routine condition inspections.

Typically, an increasingly higher level of expertise is used in interpretation of results as the inspection progresses. Primary structural components receive a detailed inspection and specialized access equipment is often required to enable the close inspection of structural elements at close range. All close proximity inspections **must** be carried out by a professional engineer or under a professional engineer's direct supervision. Ensure that the professionals providing this service have the mandatory knowledge and skills requirements listed under service category P06 Professional Condition Inspection and Evaluation of Forest Road Bridges and Major Culverts (PDF) of the ministry's Engineering Equipment & Services (EES) Directory.

6.5.2 Structural Deficiencies Noted in Inspections for FSR Structures

A sequence for identifying and correcting structural deficiencies in engineered structures is:

- a qualified inspector identifies and records possible structural deficiencies and specifies on the inspection forms if a follow-up inspection by a professional engineer is required to evaluate the deficiencies. Bring any structural deficiencies which may pose an immediate risk to users to the attention of the TSM/District Manager, as soon as possible;
- ensure that the ministry bridge engineer reviews the inspection reports and determines whether a follow-up professional inspection is warranted. If the decision is no, ensure that the ministry bridge engineer generates a letter to the local office, stating the findings and making recommendations as appropriate. If a follow-up professional inspection is required, ensure that the professional engineer who subsequently carries out the field review recommends, as applicable:
    - the work to be carried out to correct the deficiencies; or
    - the need to protect road users by either:
        - installing signs detailing the load rating prepared by the professional engineer (see Warning Load Limit sign FS 639a (PDF)); or
        - closing a bridge to traffic or removing a structure.
- Where the ministry bridge engineer determines that a bridge will be posted as downrated or a structure is being recommended for closure or removal, the ministry bridge engineer advises the TSM/District Manager accordingly as soon as possible.

6.5.3 Clarification of GVW as Applicable to Bridge Load Rating

Gross vehicle weight (GVW) is the total weight of the vehicle including cargo. Load rating for a structure typically involves complex calculations and judgement and then distilling the results down to a simple number (typically a maximum GVW). Because of the limited information included on a load rating sign, users can often misinterpret the load restriction. This bulletin is intended to provide clarity for the meaning of gross vehicle weight, as applicable to bridge load rating.

Gross vehicle weight (GVW) load ratings for bridge structures are typically based on the BCFS L-series design vehicles. The BCFS L-series design vehicles are not "real" vehicles but are intended to be "envelope" logging truck vehicles which capture the force effects of the population of "normal" logging trucks. Force effects from load configurations consisting of other types of vehicles, such as yarders and excavators, are not typically captured by the design vehicles. Equipment crossings of this nature should be evaluated by a professional engineer on a bridge by bridge basis.

The L-series design configurations were founded on imperial ("short") tons (as opposed to "long" metric tonnes and kilograms). For example, a BCFS L-75 has a GVW of 75 imperial tons which is equal to 68 tonnes or 68,040 kilograms.

There are a number of design vehicle configurations which have been utilized over time. Some of these are no longer used to design new structures. There are, however, existing structures which were designed using these configurations that are still in service. Primary examples include the BCFS L-45 and BCFS L-60.

The CL 625 and BCL 625 highway vehicle design configurations are exceptions to typical logging truck configurations. These configurations are drawn from the Canadian Highway Bridge Design Code (CSA S6) and BC Ministry of Transportation and Infrastructure. These highway vehicle configurations were adopted by the Ministry of Forests, Lands and Natural Resource Operations in order to be consistent with MoTI design configurations for highway loads. Bridges designed to these loads are considered to have sufficient capacity to support provincial highway legal loads.

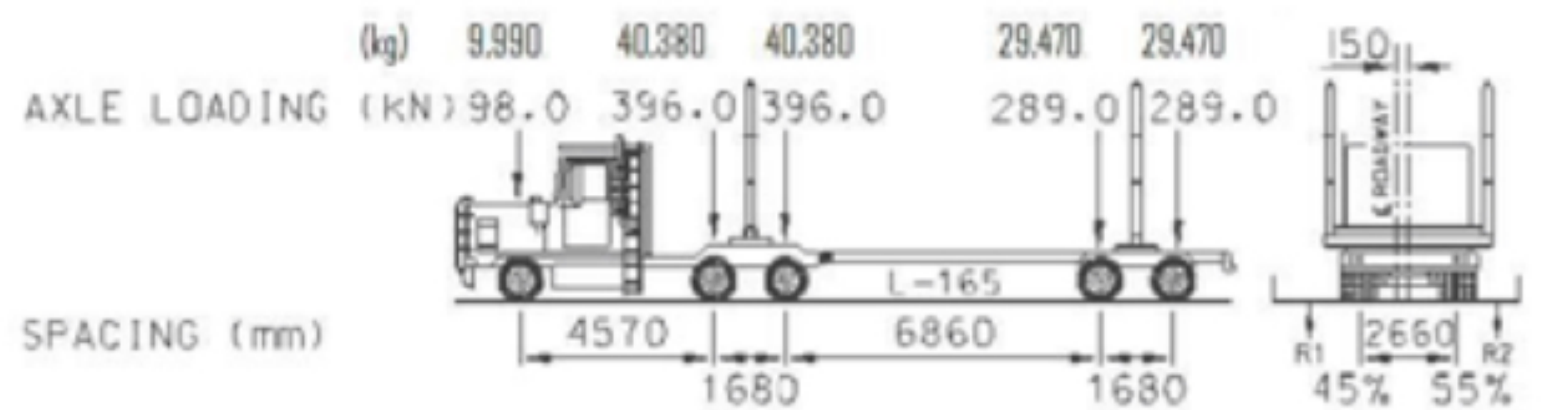
The following table provides a comparison of different design vehicle GVWs for short (English) tons, kilonewtons, kilograms and long (metric) tonnes.

Gross vehicle weights for design vehicle configurations

Design Vehicle Configuration	**Gross Vehicle Weight**			
	Tons (imperial)	**Kilonewtons (kN)**	**Kilograms (kg)**	**Tonnes (metric)**
BCFS				
L-45	45	408.2	40,820	41
L-60	60	533.8	54,430	54
L-75	75	667.2	68,040	68
L-100	100	889.6	90,680	91

L-150	150	1334.6	136,090	136
L-165	165	1468	149,700	150
CSA-S6 Canadian Highway Bridge Design Code				
CL-625	70	625	63,732	64
Ministry of Transportation - modified from CSA-S6				
BCL-625	70	625	63,732	64

A bridge structure that is load rated to a specified GVW does not mean that the structure can safely pass any vehicle with a weight equal to or lesser than the GVW. A load rating is dependent on the assumed axle configuration and weight distribution between axles. The design vehicles on which the GVWs are based have their load distributed over a number of axles over the length of the vehicle. A bridge that is shorter than the design vehicle would not have all of the axles of the vehicle on the bridge simultaneously and thus the full vehicle GVW would not be on the bridge. The force effect is dependent on the axle or axle group loads on the bridge rather than the overall GVW. Further, the bridge may not have the capacity to support a concentrated load of equal weight to the posted maximum GVW, such as a large tracked machine.



Example Design Vehicle Loading Diagram - BCFS L-165 (GVW 149,700 KGs)

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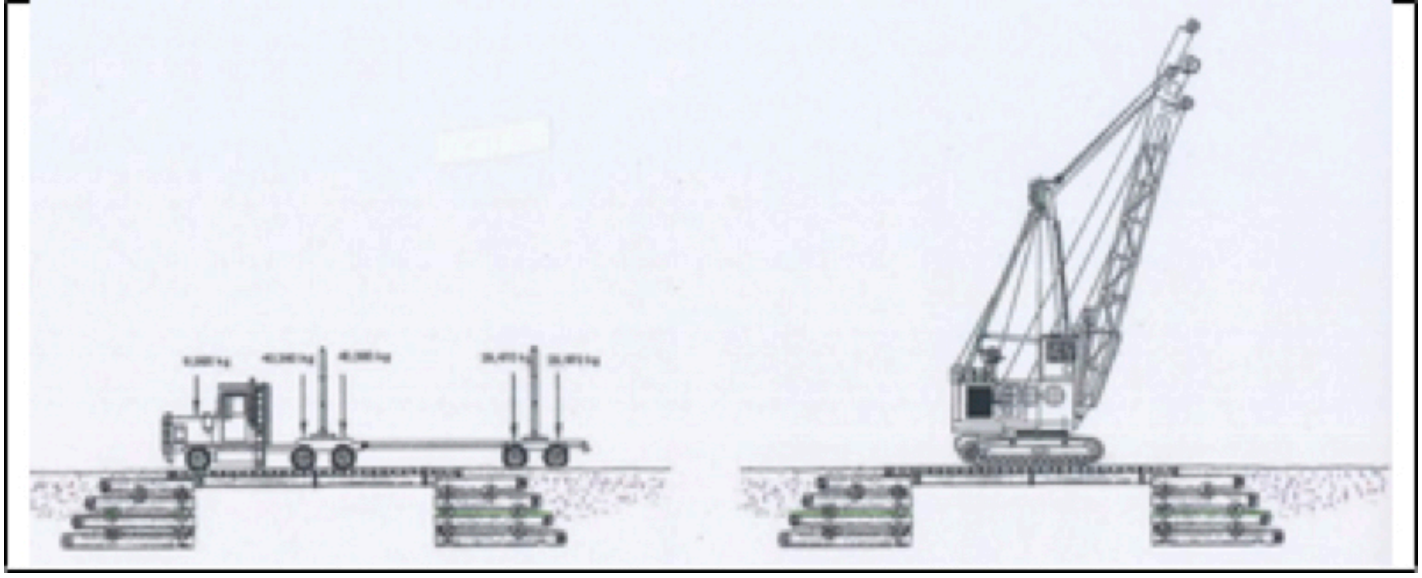
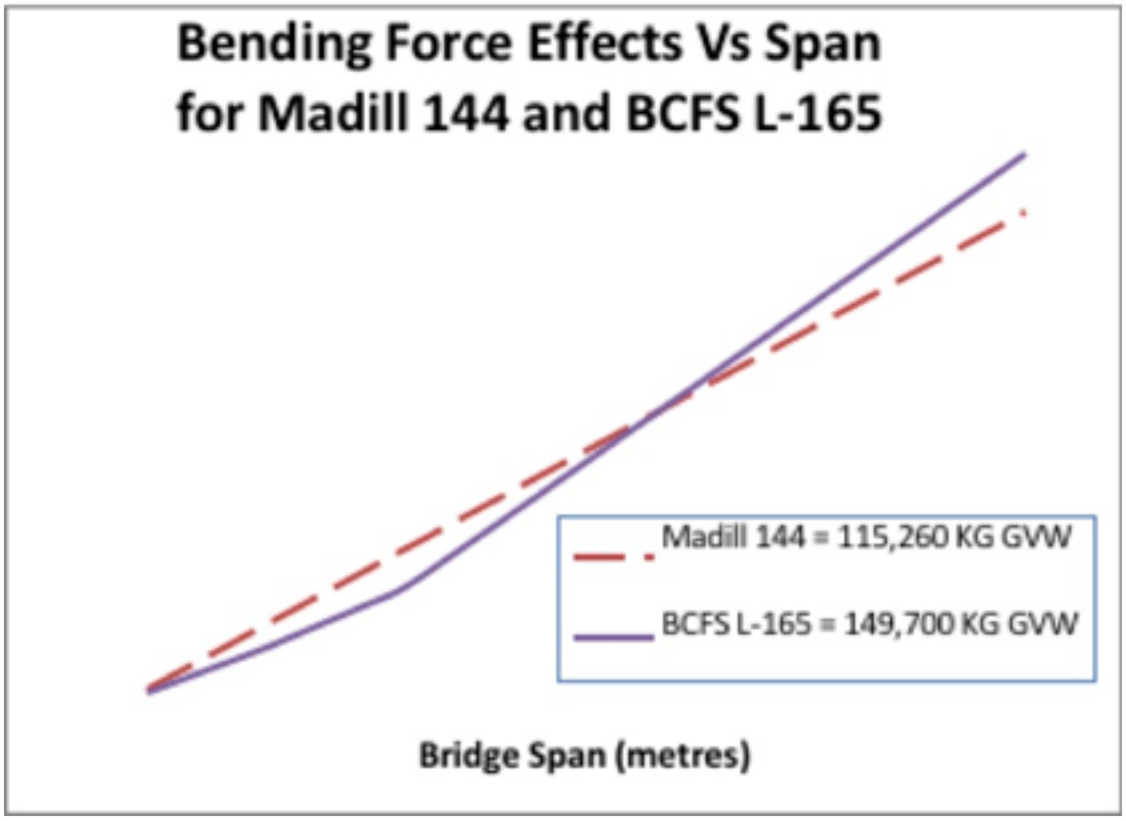
Forest effects of design vehicles versus concentrated equipment loads



The graphic above shows a 10-metre span bridge with a L-165 truck on the left and a 144 Madill Yarder on the right. The vehicles are positioned where the maximum bending force effect would occur on the bridge. As you can see, the truck only has the front three axles (with a combined weight of 90,680 kilograms) on the bridge, whereas the full yarder (GVW 115,620 kilograms) is on the bridge at its centre. The yarder generates a force effect of 2,168 KN*m while the truck only generates 1,670 KN*m. The yarder bending force effect is 130% of the logging truck. A 10 metre bridge designed for L-165 loading would not have adequate capacity for a Madill 144 yarder.

Note: The following graph of bending force effects versus bridge span is provided for illustrative purposes only and is **not to be used to interpret allowable loads** for application to any actual structure.



The graph shows the bending force effects arising for a 144 Madill yarder with a GVW of 115, 260 kilograms as compared to a BCFS L-165 logging truck configuration with a GVW of 149,700 kilograms. Although the yarder has a significantly lower GVW, the resulting bending force effects are significantly greater than that of the heavier L-165 logging truck for shorter span bridges. This result is due to the concentration of the weight of the yarder over a shorter length. In contrast, the logging truck does not have all of its axles on the shorter span bridges. As the bridge length increases, more truck axles come into play on the bridge, resulting in the bending force effects of the logging truck surpassing those of the yarder.

Road network design vehicle load rating

Typically, road networks have a specified design vehicle load configuration identified. All bridge structures would be designed for the specified design vehicle load. There have been incidents where a bridge with a lower design load has been installed at the beginning of the road network. This can effectively result in the lower design load restricting access on the full road network.

The design vehicle load configuration for Forest Service Roads would ideally be posted at the commencement and other entrances to the road. Only bridges which were not capable of meeting that design vehicle load would be posted with a sign specifying an allowable safe GVW which has been determined by a Professional Engineer. New guidance is being developed for road signage and will be available in the foreseeable future.

Safe vehicle passage

Any concerns for safe capacity of bridge structures should be brought to the attention of a ministry field engineer. Where it is uncertain whether a particular vehicle can safely cross a bridge, a professional engineer should be consulted to assess the structure for the specific vehicle. For any structure that has been down rated, professional engineering advice is critical to avoid errors in interpretation. Failure to assess the carrying capacity of a bridge can have disastrous results as exemplified in the picture below.

6.5.4 Engineered Structure Inspection Frequencies

For the purposes of determining inspection frequencies, ministry engineered structures are categorized as “Permanent” or “Temporary” - see Definitions in Chapter 4.

Unless a professional engineer specifies otherwise:

- Permanent structures (excepting log / woodbox culverts) **must** be inspected by a qualified Inspector at least once every three years, and a record of the inspection made, unless access to the structure is prevented by a man-made or naturally occurring barricade or blockage.

  Note: Provided that its stringers or girders are comprised of permanent materials, a bridge is categorized as a permanent structure even though it may have untreated timber deck cross-ties and / or untreated timber sills bearing on an abutment that is comprised of permanent materials.

- Temporary retaining structures, bridges and log / woodbox culverts that are defined as major culverts (Section 4.2 - log stringer/gravel deck structure with a span less than 6m and a design discharge of 6m3/s or greater) **must** be inspected at least once every two years, and a record of the inspection made, unless access to the structure is prevented by a man-made or naturally occurring barricade or blockage.

In addition to regular scheduled inspections, inspect structures after severe storm events.

Where warranted, structure inspection frequency can be increased to be more often to provide for increased monitoring, such as when a structural element is nearing the end of its service life, or where conditions exist which merit more frequent inspections as may be suggested by an inspector or determined by a professional engineer.

6.5.5 Engineered Structure Inspection Reports

Include the following in the inspection record of an engineered structure:

- date of the inspection;
- a condition assessment of the components of the structure, including bridge approaches, and considering among other things the length of time a structure has been at its current site;
- a recommendation for any repairs that may be required and a schedule for those repairs;
- the date of the next scheduled inspection provided by the reviewing professional engineer;
- inspector’s signature; and
- professional engineer’s signature and date.

The inspection records are used to identify current maintenance requirements as well as track the condition of the structure and required maintenance over time. Take illustrative photos during the inspection and provide a visual aid for the professional engineer evaluating the structure condition. Photos of deficiencies or suspect problems are particularly useful. The photos also provide an opportunity to track progression of condition of various structure components over time (such as abutment erosion).

Retain inspection records for engineered structures for one year beyond the actual life of the structure, or for portable bridge superstructures, the records should be retained with the superstructure records for one year beyond the actual life of the superstructure. Should a structure fail, these records will be useful in any subsequent investigation. Additionally, use the inspection records as a reference to determine the type of structures that are cost-effective and environmentally suitable for similar stream crossings.

Review the recommendations to ensure that the maintenance works comply with legislation. Ensure that the appropriate electronic bridge register is updated, that signed original inspection reports are provided for the project files, and that the local FLNR manager is advised of any structural issues that would impact ongoing use.

For bridge inspections, use the applicable ministry form available from the ministry form index:

- FS1337A - Log Stringer or Timber Stringer Bridges (PDF, 1.3MB)
- FS1337B – Bridges Except for Log Stringer or Timber Stringer Bridges (PDF, 1.3MB)
- FS1337C - Culvert Inspection (PDF, 1.2MB)

Place copies of the completed inspections, signed by the inspector and professional engineer, on the appropriate Operational Records Classification System (ORCS) files and/or entered into the bridge register.

Where the responsibility for maintenance has been delegated to a Road Use Permit (RUP) holder, forward a copy of the inspection report, along with a District Manager’s covering letter highlighting any structural deficiencies, to the RUP holder. Where structural deficiencies are such that there is a risk to users, advise the RUP holder immediately, in the most expedient way, that there is a problem with the structure.

When structural repairs are completed, ensure that an inspection of the completed works is carried out and a new inspection report generated for review by a ministry bridge engineer. Where time is not of the essence, consider carrying out the inspection of these works as part of a future road inspection.

6.5.6 Engineered Structure Inspection Documentation

Place signed originals of final engineered structure inspection reports on the hardcopy project file. Also, place any follow-up documentation on the file.