

# Bridge Evaluation Guidelines

## Version 2024-1



## Preface

This document is intended be a supplement to Section 14 of CSA Standard S6:19 (S6) and to Section 2 of Ministry of Highways, Bridge Design Criteria.

The evaluator shall use sound engineering judgment in the application of these guidelines.

## Version

<b>VERSION</b>	<b>RECOMMENDED BY/DATE</b>	<b>TECHNICAL CONTENT APPROVED BY / DATE</b>
2016-03-10	Greg Lang/March 10,2016	
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## Change History

Date	Description
Mar, 2016	
Oct. 2018	<ul style="list-style-type: none"><li>• Minor formatting and reorganization of the content</li><li>• Revise wording Cl 1.1.1 to clarify intent of guidelines are for existing bridges</li><li>• Cl 4.6.1.3 to 4.6.1.8, incorporate changes proposed for 2019 version of the Canadian Highway Bridge Design Code which eliminates the short span load factors and adds a multiplier for all axle loadings within a 6 m length of the vehicle.</li><li>• Cl 4.6.3.3.3, eliminate the need to increase the axle loads when the permit request provides scaled weights.</li><li>• Cl 4.6.2.3.2, establish maximum limits for axle groups for bulk haul vehicle permit requests.</li><li>• Cl 4.6.2.4.2, establish maximum limits for axle groups for timber haul vehicles.</li><li>• Cl 4.6.3.2.1.3, provides some guidance when posting the load limits of a bridge is required.</li><li>• Cl 4.6.3.4.2, guidance to use cost benefit analysis, when replacing or strengthening is required</li><li>• Cl 4.8.4, additional guidance when determining the resistance adjustment factor</li><li>• Cl 5.2.2.2, clarifies the description of the location of the critical element</li><li>• Cl 5.2.3, clarifies the requirements for the outputs of the load evaluation</li><li>• Figure BE-1, revise weight of steering and drive axle</li><li>• Figure BE-2A, breakdown of truck configuration for short span bridges.</li></ul>
Feb. 2024	<ul style="list-style-type: none"><li>• Table BE-1, Removed Short Span factors, and changed Other spans and Long Spans to All spans.</li><li>• Cl 4.7.2, added to clarify Ministry of Highways policy on Target Reliability Index, <math>\beta</math>, for the PC traffic category.</li><li>• Cl 4.7.1, removed “short span” and “other span” from appropriate clauses.</li></ul>

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## BE100 Bridge Evaluation Guidelines

### 1.0 SCOPE

1.1. These guidelines cover load evaluations used for the following purposes:

1.1.1. Establishing Load Limits

Evaluation of existing bridges to determine their load carrying capacity at the ultimate limit state (ULS). Results are used to establish load limits for standard vehicle configurations operating under Permit-Bulk Haul (PB), Annual or Project (PA), Permit-Single Trip (PS) or Permit-Controlled (PC) traffic categories and evaluation of existing bridges to identify deficiencies in capacity based on their ability to carry the Ministry of Highway's normal traffic vehicle configurations.

1.1.2. Permit Review

Evaluation of existing bridges to assess their ability to carry overweight vehicles operating under an overweight permit or Ministry of Highways partnership agreement.

1.1.3. Bridge Design

Evaluation of new bridge designs to assess their ability to carry the Ministry of Highway's normal traffic vehicle configurations and/or the Ministry of Highway's proposed bulk haul vehicles for bridge analysis (PB).

1.1.4. Bridge Strengthening Study

To establish strengthening requirements in order to achieve a capacity that will provide a desired level of service for each traffic category.

1.2. Evaluations to determine load carrying capacity at serviceability limit states or at the fatigue limit state are not covered by these guidelines.

1.3. Evaluation procedures and methodologies are provided as guidelines only. In each case, the evaluator shall use sound engineering judgment as to whether they apply to a particular structure.

## 2.0 BRIDGE EVALUATION STANDARD

- 2.1 Evaluations shall be undertaken in accordance with Section 14 of CSA-S6 Canadian Highway Bridge Design Code and Section 2 of Ministry of Highways, Bridge Design Criteria.

## 3.0 BRIDGE SPAN TYPES

- 3.1 Several bridge span types make up the Ministry of Highways bridge inventory. Evaluation records, notes, calculations etc. for each bridge are categorized and filed in separate design books by the following bridge span types:

- 3.1.1 Structural steel trusses: Design Book 230A
- 3.1.2 Reinforced concrete arches: Design Book 231A
- 3.1.3 Structural steel plate girders: Design Book 232A
- 3.1.4 Reinforced concrete T-Beams: Design Book 233A & 233B
- 3.1.5 Reinforced concrete girders: Design Book 234A
- 3.1.6 Reinforced concrete flat slabs: Design Book 235A
- 3.1.7 Pre-engineered precast reinforced concrete stringers: Design Book 236A
- 3.1.8 Pre-engineered precast prestressed concrete stringers: Design Book 236A
- 3.1.9 Miscellaneous precast concrete girders: Design Book 236B
- 3.1.10 Continuous precast concrete girders: Design Book 237A
- 3.1.11 Precast prestressed concrete AASHTO girders: Design Book 237B
- 3.1.12 Timber stringers: Design Book 238
- 3.1.13 Wide flange structural steel girders: Design Book 239A
- 3.1.14 Miscellaneous (bridges with multiple span types or unique one-off span types): Design Book 240

## 4.0 EVALUATION PROCEDURES

### 4.1 General

4.1.1 All evaluations shall be performed and checked by qualified engineers and reviewed by a bridge engineer experienced in bridge evaluation.

4.1.2 All evaluations shall use ultimate limit states methods to determine load-carrying capacity.

4.1.3 Only dead load and live load effects need to be considered for evaluations.

### 4.2 Condition Inspection

4.2.1 Bridge condition shall be based on the latest bridge inspection report located in the Ministry of Highways bridge file.

4.2.1.1 If bridge inspection information on file is incomplete or conflicting, the evaluator shall arrange for a detailed inspection in order to assess any loss of capacity due to condition.

4.2.1.2 The evaluator may consider performing the detailed inspection in person in order to improve the Inspection Level.

### 4.3 Critical Elements

4.3.1 All critical primary load carrying superstructure elements, except for reinforced concrete deck slabs and timber flooring, shall be evaluated. Secondary bracing members shall be evaluated only if there is a loss of capacity due to condition and they contribute to an improved lateral distribution of live load used in a sophisticated analysis of a primary load carrying member.

4.3.2 Critical substructure elements located above ground including structural bearings shall be evaluated only when there is a loss of capacity due to condition. Substructure elements located below ground are not to be included in the evaluation.

### 4.4 Material Properties

4.4.1 See Appendix C, Table BE-2 for evaluation aids developed by the Ministry of Highways to assist in determining material properties for reinforced concrete.

4.4.2 In addition to CSA-S6, Table 14.2, for bridges in Saskatchewan assume intermediate grade reinforcing steel starting in 1929 unless specified otherwise.

## 4.5 Dead Loads

- 4.5.1 Dead loads shall be based on the information provided on the plans and/or in the Ministry of Highways bridge file including field measurements recorded in inspection reports. Any modifications to the bridge done after the original construction shall be taken into account.

## 4.6 Live Load

### 4.6.1 General

- 4.6.1.1 All evaluations shall consider multiple-lane loading as per Section 14.9.4 of CSA-S6 and Section 2 of Ministry of Highways, *Bridge Design Criteria*.

4.6.1.1.1 For a permit vehicle with normal traffic, the loading to be applied to the other lanes shall be taken as a fraction of CL1-625 loading as specified by CSA-S6, Table 14.4.

- 4.6.1.2 For lateral distribution of live load, use the statically determinate method or simplified method, whichever is applicable. Use the sophisticated method only for bridges that do not meet the criteria for using the simplified method, or when a more detailed evaluation is required to determine load restrictions, or strengthening options.

- 4.6.1.3 For vehicles evaluated under the Normal Traffic (NP) category, the loading to be used for evaluation shall be the more severe of:

4.6.1.3.1 The vehicle with dynamic load allowance in accordance with CSA-S6 3.8.4.5 as a special truck.

4.6.1.3.2 All specified axle loadings within any 6 m length of the vehicle increased by a factor of 1.34, with dynamic load allowance in accordance with CSA-S6:19 3.8.4.5 as a special truck.

4.6.1.3.3 80% of the vehicle plus a superimposed uniformly distributed load of 9 kN/m without dynamic load allowance for either the vehicle or uniformly distributed loads.

- 4.6.1.4 For the lane carrying vehicles evaluated under the Bulk Haul (PB) category, the load effect shall be calculated from the more severe of:

4.6.1.4.1 The permit vehicle alone in the lane with dynamic load allowance in accordance with CSA-S6:19 Clause 14.9.3.

- 4.6.1.4.2 All specified axle loadings within any 6 m length of the vehicle increased by a factor of 1.06, with dynamic load allowance in accordance with CSA-S6:19 Clause 14.9.3.
- 4.6.1.4.3 80% of the permit vehicle plus a superimposed uniformly distributed load of 9 kN/m without dynamic load allowance for either the vehicle or uniformly distributed loads.
- 4.6.1.5 For vehicles evaluated under the Annual or Project (PA) category, the load effect shall be calculated from the more severe of:
  - 4.6.1.5.1 The permit vehicle alone in the lane with dynamic load allowance in accordance with CSA-S6:19 Clause 14.9.3.
  - 4.6.1.5.2 All specified axle loadings within any 6 m length of the vehicle increased by a factor of 1.12, with dynamic load allowance in accordance with CSA-S6:19 Clause 14.9.3.
  - 4.6.1.5.3 85% of the permit vehicle plus a superimposed uniformly distributed load of 9 kN/m without dynamic load allowance for either the vehicle or uniformly distributed loads.
- 4.6.1.6 For vehicles evaluated under the Single Trip (PS) category, the load effect shall be calculated from the more severe of:
  - 4.6.1.6.1 The permit vehicle alone in the lane with dynamic load allowance in accordance with CSA-S6:19 Clause 14.9.3.
  - 4.6.1.6.2 All specified axle loadings within any 6 m length of the vehicle increased by a factor of 1.12, with dynamic load allowance in accordance with CSA-S6:19 Clause 14.9.3.
  - 4.6.1.6.3 85% of the permit vehicle plus a superimposed uniformly distributed load of 9 kN/m without dynamic load allowance for either the vehicle or uniformly distributed loads.
- 4.6.1.7 For vehicles evaluated under Controlled (PC) category, the load effect shall be calculated from the more severe of:
  - 4.6.1.7.1 The permit vehicle alone in the lane with dynamic load allowance in accordance with CSA-S6:19 Clause 14.9.3.

4.6.1.7.2 All specified axle loadings within any 6 m length of the vehicle increased by a factor of 1.08, with dynamic load allowance in accordance with CSA-S6:19 Clause 14.9.3.

4.6.1.7.3 Lane loading shall not be considered for PC traffic.

#### 4.6.2 Traffic Categories

4.6.2.1 Bridges subject to legal loading on primary, secondary or municipal highways shall be evaluated under the Normal Traffic category.

4.6.2.2 Bridges subject to loading from overweight term permit vehicles shall be evaluated under the Permit-Annual or Project (PA) category.

4.6.2.3 Bridges subject to loading from overweight bulk commodity haul vehicles authorized by a Ministry of Highways partnership agreement shall be evaluated under the Permit-Bulk Haul (PB) category.

4.6.2.3.1 Contrary to CSA-S6 Section 14.9.2.4, axle loads may exceed the legislated limits (legal load).

4.6.2.3.2 Axle group loads shall be limited to the following maximum weights:

4.6.2.3.2.1 Tridem group 26,000 kg

4.6.2.3.2.2 Tandem group 20,000 kg

4.6.2.3.3 Contrary to CSA-S6, Table 14.8, Live Load factors for the PB traffic category shall be the factors shown in Table BE-1 “Summary of Load Factors to be used for Ministry of Highways Evaluations”.

4.6.2.4 In addition to CSA-S6, Section 14.9.2.1, vehicles operating under a Ministry of Highways partnership agreement authorizing overweight round-log timber haul shall be classified as Permit-Timber Haul in accordance with the following:

4.6.2.4.1 Timber Haul vehicles shall include round-log timber haul divisible load traffic authorized by a Ministry of Highways partnership agreement for many trips, mixed with general traffic.

For the lane carrying the Timber haul vehicle, the load effect shall be calculated from the more severe of:

4.6.2.4.1.1 the permit vehicle alone in the lane with dynamic load allowance, in accordance with CSA-S6, Section 14.9.3; or

4.6.2.4.1.2 80% of the permit vehicle, plus a superimposed uniformly distributed load of 9, 8, 7 and 7 kN/m for highways classes A, B, C and D respectively, without dynamic load allowance for either Truck or uniformly distributed loads.

4.6.2.4.2 Axle group loads shall be limited to the following maximum weights:

4.6.2.4.2.1 Tridem group 32,000 kg

4.6.2.4.2.2 Tandem group 25,000 kg

4.6.2.4.3 Live Load factors for the Timber Haul traffic category shall be the factors shown in Table BE-1 “Summary of Load Factors to be used for Highways Evaluations”.

4.6.2.5 Bridges subject to loading from overweight single trip permit vehicles shall be evaluated under the Permit-Single Trip (PS) category.

4.6.2.6 Bridges subject to loading from supervised, conditional, overweight single trip permit vehicles shall be evaluated under the Permit-Controlled (PC) category.

#### 4.6.3 Vehicle Configurations

4.6.3.1 Live load configurations for establishing load limits shall conform to Ministry of Highways typical vehicle configurations for the traffic category being considered. See Appendix A, Figures BE-2, BE-3 and BE-4 for details of the typical vehicle configurations for evaluating bridges under the PS, PB and PC traffic categories.

4.6.3.1.1 When evaluating elements with short influence lines (influence lines equal to or less than 18.0 m in length), bridges shall be evaluated with the Clause b configurations as shown in Appendix A, Figure BE-2A with the magnification factors as per CSA-S6:19 Cl 14.9.2.2 b). In addition to the partial truck configurations the single, tandem, and tridem axle groups shall be evaluated with the magnification factor.

To establish load limits for the complete PS trucks, combine the results from the partial trucks and/or axle groups. The governing truck configuration will be the truck with the lowest GVW.

4.6.3.2 Live load configurations for determining deficiencies in existing bridges shall conform to the Ministry of Highway's typical Normal Traffic vehicle configurations. See Appendix A, Figures BE-1, BE-1A and BE-1B for details of the typical vehicle configurations.

4.6.3.2.1 If it is determined that a critical element is deficient for typical Normal Traffic vehicle configurations for use on Primary Highways, a more detailed analysis is required.

4.6.3.2.1.1 If the bridge is located on a Secondary or Municipal Highway, re-evaluate the deficient critical element using the appropriate typical Normal Traffic vehicle configurations to determine if it is deficient for legal load.

4.6.3.2.1.2 Contrary to CSA-S6, Section 14.15.2, for Normal Traffic, the live load capacity factor,  $F$ , shall be calculated for the loading due to the Ministry of Highway's typical Normal Traffic configurations.

4.6.3.2.1.3 If the critical element is deficient for legal load, i.e. if the live load capacity factor,  $F$ , is less than 1.0, the bridge shall be posted until such time that the bridge can either be replaced or strengthened.

4.6.3.2.1.4 Posting limits shall be based on the live load capacity factors calculated for the Ministry of Highway's typical Normal Traffic vehicle configurations.

- 4.6.3.2.1.5 Further to CSA-S6, Section 14.17.3 posting signs shall be as directed by the Ministry of Highways.
- 4.6.3.3 Live load configurations for permit reviews shall conform to one of the following:
- 4.6.3.3.1 The vehicle configurations submitted with a request for a term or single trip overweight permit as forwarded to Ministry of Highways, Bridge Branch, Regina Office by the SGI Permit Office.
  - 4.6.3.3.2 The proposed vehicle configurations to be operated under a Ministry of Highways partnership agreement for bulk commodity haul as forwarded to Ministry of Highways, Bridge Branch by Ministry of Highways, Trucking Programs Section.
  - 4.6.3.3.3 When evaluating for a permit review, S6 no longer allows a modification factor for scaled loads
- 4.6.3.4 Live load configurations for assessing new designs shall conform to the Ministry of Highway's typical Normal Traffic vehicle configurations for use on Primary Highways and Permit – Bulk Haul (PB) vehicle configurations for evaluation of new designs. See Appendix A, Figures BE-1, and BE-3A for details of the typical vehicle configurations.
- 4.6.3.4.1 Use the following iterative process to determine the target capacity if strengthening is determined to be the most cost effective solution:
    - 4.6.3.4.2 Live load configurations for determining the target capacity for strengthening as part of a bridge strengthening study shall conform to the Ministry of Highway's typical Permit – Single Trip (PS) vehicle configurations. See Appendix A, Figure BE-2 for details of the standard vehicle configurations.
    - 4.6.3.4.3 A life-cycle cost analysis shall be done to determine the most cost effective solution of either replacing the bridge or strengthening the deficient critical elements.
      - 4.6.3.4.3.1 Establish a set of trucks based on axle group weights equal to approximately 80% to 90% of the maximum single trip permit weights for typical PS truck configurations documented in the previous one to two years.

- 4.6.3.4.3.2 Evaluate the deficient critical element under the PS traffic category with the established set of PS trucks to determine the factored capacity required to accommodate the PS loading.
- 4.6.3.4.3.3 Establish PS load limits by evaluating the critical element for the typical PS vehicle configurations assuming the element has been strengthened to the factored capacity determined above.
- 4.6.3.4.3.4 Confirm that 80% to 90% of all single trip permit requests for that route documented in the previous one to two years will be accommodated.
- 4.6.3.4.3.5 Typically, if 80% to 90% of all single trip permit requests for that route documented in the previous one to two years cannot be accommodated, then adjust the axle group loads of the previously established set of PS trucks and repeat the process.
- 4.6.3.4.3.6 Repeat as necessary until a target capacity is determined.

## 4.7 Target Reliability Index

4.7.1 In addition to CSA-S6, section 14.12, use the following Ministry of Highways policies for determining System Behaviour and Element Behaviour categories:

4.7.1.1 Use System Behaviour Category S2 for the following:

- 4.7.1.1.1 Continuous 2 girder plate girder bridges in flexure and shear.
- 4.7.1.1.2 Multi-beam bridges or continuous main members in bending with the exception of standard prestressed precast box girders.
- 4.7.1.1.3 Floor beams in trusses.

4.7.1.2 Use System Behaviour Category S3 for the following:

- 4.7.1.2.1 Standard prestressed precast concrete box girders in flexure and shear.

4.7.1.3 Use Element Behaviour Category E2 for the following:

4.7.1.3.1 Timber bridges

4.7.1.4 Use Element Behaviour Category E3 for the following:

4.7.1.4.1 Prestressed concrete members

4.7.2 The Ministry of Highways policy for determining the Target Reliability Index,  $\beta$ , for the PC traffic category is as follows:

4.7.2.1 For grade separated structures including railway overpasses the Target Reliability Index,  $\beta$ , shall be reduced by 0.25 as per CSA-S6, Section 14.12.1.

4.7.2.1.1 The Target Reliability Index,  $\beta$ , may be reduced by another 0.25 upon review by Ministry of Highways staff.

4.7.2.2 For all other structures the Target Reliability Index,  $\beta$ , shall be reduced by 0.5 as per CSA-S6, Section 14.12.1.

## 4.8 Element Resistances

4.8.1 Determine factored resistances in accordance with the applicable sections of CSA-S6.

### 4.8.2 Steel Beams and Girders

4.8.2.1 Further to Section 10.10.1.3 of CSA-S6, the concrete fillet along the edges of the top flange of steel girders at the deck slab girder haunch shall not be considered to provide lateral support to the girder.

4.8.2.2 Further to Section 10.10.5.1,  $F_t = 0$  when  $F_{yf} > F_{yw}$  i.e. a hybrid girder

Where:

4.8.2.2.1  $F_{yf}$  = the specified minimum yield stress of the flange steel

4.8.2.2.2  $F_{yw}$  = the specified minimum yield stress of the web steel

This requirement can be waived for short, unintended hybrid sections located between flange and web butt splices if the factored stress in the flange steel is limited to the resistance factor for steel in flexure multiplied by the specified minimum yield stress of the web steel ( $\phi_s F_{yw}$ ).

4.8.2.3 Contrary to Section 10.11.6.2.1 of CSA-S6, positive moment resistance of composite beams and girders with Class 3 steel sections shall be limited to the moment at first yield as per Ministry of Highways policy.

4.8.3 Reinforced Concrete Beams and Girders

4.8.4 Further to CSA-S6 Table 14.15,

$\rho_b = [(\alpha_1 \cdot f'_c \cdot \beta_1) / f_y] \cdot [(700 / (700 + f_y))]$  when determining the resistance adjustment factor, U, for reinforced concrete in bending.

## 5.0 EVALUATION REPORTS

5.1 General

5.1.1 A report signed and sealed by a professional engineer with experience in load evaluation shall be submitted to the Ministry of Highways documenting the evaluation results.

5.1.2 Information contained within the report will differ for each type of evaluation. The results of each type of evaluation shall contain the following documentation:

5.2 Evaluations for Establishing Load Limits

5.2.1 A bridge description including the following:

5.2.1.1 Location of crossing (e.g. Hwy 4 over Hwy 16)

5.2.1.2 Control Section

5.2.1.3 km

5.2.1.4 Bridge file No.

5.2.2 A summary of the governing critical elements including the following:

5.2.2.1 Element description (e.g. reinforced concrete girder)

5.2.2.2 Location (e.g. distance to end support)

5.2.2.3 Mode of failure (e.g. flexure)

5.2.2.4 Factored Resistance

5.2.2.5 Traffic category for live load

#### 5.2.2.6 Lateral live load distribution

### 5.2.3 All evaluation calculations and notes including:

#### 5.2.3.1 Calculation of loads

5.2.3.1.1 Dead load calculations including unit weights, member sizes, Bridge Plans used to determine bridge details, etc.

5.2.3.1.2 Live load lateral distribution category

5.2.3.1.3 Live load lateral distribution values used in analysis

5.2.3.1.4 Dynamic load allowance

#### 5.2.3.2 Calculation of member resistances for each critical element

5.2.3.2.1 Location of critical element

5.2.3.2.2 Determination of material strengths

5.2.3.2.3 Determination of member sizes and cross-sectional properties

5.2.3.2.4 Determination of mechanical properties

5.2.3.2.5 Capacity reductions due to condition

#### 5.2.3.3 Determination of load factors

5.2.3.3.1 System behaviour

5.2.3.3.2 Element behaviour

5.2.3.3.3 Inspection level

5.2.3.3.4 Target Reliability Index

#### 5.2.3.4 Software analysis

5.2.3.4.1 Type of software

5.2.3.4.2 Data inputs

5.2.3.4.3 Outputs

- 5.2.3.4.4 Assumptions
- 5.2.3.4.5 Constraints
- 5.2.3.4.6 Steps involved for the evaluation process
- 5.2.3.5 Calculation of load limits for each vehicle configuration
- 5.2.3.6 Calculation of Live Load Capacity Factors for each Normal Traffic vehicle configuration
- 5.2.3.7 Summary of critical elements deficient for Normal Traffic for Primary Highways
- 5.2.3.8 Summary of critical elements deficient for legal load if not on a Primary Highway (Secondary or Municipal Highways)
- 5.2.4 Load Limit curves using the Ministry of Highway's standard templates. See Appendix C, Figures BE-6 and BE-7 for details of the templates. Templates are available in electronic form. Complete the template with the following Information:
  - 5.2.4.1 Location of crossing (e.g. Hwy 4 over Hwy 16)
  - 5.2.4.2 Control Section
  - 5.2.4.3 Bridge Plan Number(s)
  - 5.2.4.4 Span Lengths
  - 5.2.4.5 Bridge Span Type
  - 5.2.4.6 Live load lateral distribution for governing elements
  - 5.2.4.7 Bridge file Number
  - 5.2.4.8 Date of evaluation
  - 5.2.4.9 Tabulated load limits for each typical vehicle configuration in each traffic category evaluated (typically PS, PB and PC categories only).
    - 5.2.4.9.1 Note that for each vehicle size there is more than one vehicle configuration. Limits are required for all configurations.

- 5.2.4.10 Plot of governing PS and PB vehicle load limit for each vehicle size (5 axle, 7 axle, 8 axle & 9 axle)
- 5.2.4.11 Plot of governing PS and PB load limit for each axle group type (single, tandem and tridem).
- 5.2.4.12 Plot of governing PC load limit for each axle configuration
- 5.2.4.13 Graphic of individual axle group weight limits and GVW limit for each PS vehicle configuration.
  - 5.2.4.13.1 For bridge elements with short influence lines evaluated with loading from partial PS vehicle configurations shown in Figure BE-2A, axle group weight limits for the front portion of the vehicle (tractor or tractor/jeep combination) are not proportional to axle group weight limits for the rear portion of the vehicle (trailer or trailer/booster combination). Use graphic template included in Figure BE-7.

### 5.3 Evaluations for Permit Reviews

- 5.3.1 Routine (GVW < 120,000 kg) Single Trip permit requests will be reviewed by Ministry of Highways staff. For each structure along the proposed route, the following is required:
  - 5.3.1.1 The requested load shall be compared to the plotted load limits of the typical PS vehicle configurations.
  - 5.3.1.2 Use engineering judgment as to whether or not the requested load has more or less load effect than the typical vehicles.
  - 5.3.1.3 If it is not readily obvious from the plot whether or not the bridge has adequate capacity to carry the requested load then an analysis must be completed to determine the Live Load Capacity Factor, F of governing critical element(s) for the requested load.
  - 5.3.1.4 The analysis shall assume the same parameters as the analysis used to establish the load limits for the typical PS vehicles unless suitable rational can be provided for any changes.
  - 5.3.1.5 All analysis and calculations shall be attached to the permit request and filed for a period of 6 months.

- 5.3.2 Special Request (GVW  $\geq$  120,000 kg) Single Trip permit requests may be reviewed by the Ministry of Highways or by an Engineering Consultant. For each structure along the proposed route, the following is required:
- 5.3.2.1 The requested load shall be compared to the plotted load limits of the typical PS vehicle configurations.
  - 5.3.2.2 Documentation of the rational used to determine whether or not the requested load has more or less load effect than the typical PS vehicles.
  - 5.3.2.3 If it is not readily obvious from the plot whether or not the bridge has adequate capacity to carry the requested load, then an analysis must be completed to determine the Live Load Capacity Factor, F of governing critical element(s) for the requested load.
  - 5.3.2.4 The analysis shall assume the same parameters as the analysis used to establish the load limits for the typical PS vehicles unless suitable rational can be provided for any changes.
  - 5.3.2.5 All documentation, analysis and calculations shall be filed in the appropriate design book for massive load permit reviews.
  - 5.3.2.6 Documentation shall be reviewed by the Director responsible for permit review or as delegated according to proper non-financial signing authority.
- 5.3.3 Bulk commodity hauls operating under a Ministry of Highways partnership agreement may be reviewed by the Ministry of Highways or by an Engineering Consultant. For each structure along the proposed route, the following is required:
- 5.3.3.1 If an existing analysis is not available or if the Ministry of Highways requests a revised analysis then load limits shall be established for the typical PB vehicle configurations providing the documentation described above.
  - 5.3.3.2 The requested load shall be compared to the plotted load limits of the typical PB vehicle configurations if available.
  - 5.3.3.3 Documentation of the rational used to determine whether or not the requested load has more or less load effect than the typical PB vehicles.

- 5.3.3.4 If it is not readily obvious from the plot that the bridge has adequate capacity to carry the requested load or if a plot is not available then an analysis must be completed to determine the Live Load Capacity Factor, F of governing critical element(s) for the requested load.
- 5.3.3.5 The analysis shall assume the same parameters as the analysis used to establish the load limits for the typical PB vehicles unless suitable rational can be provided for any changes.
- 5.3.3.6 All documentation, analysis and calculations shall be filed in the appropriate design book for bulk commodity hauls.
- 5.3.4 Round-log timber hauls operating under a Ministry of Highways partnership agreement may be reviewed by the Ministry of Highways or by an Engineering Consultant. For each structure along the proposed route, the following is required:
  - 5.3.4.1 An analysis must be completed to determine the Live Load Capacity Factor, F of governing critical element(s) for the requested load.
  - 5.3.4.2 The analysis shall assume the same parameters as the analysis used to establish the load limits for the typical PB vehicles unless suitable rational can be provided for any changes.
  - 5.3.4.3 All documentation, analysis and calculations shall be filed in the appropriate design book for bulk commodity hauls.
- 5.4 Evaluations for New Bridge Design
  - 5.4.1 A bridge description including the following:
    - 5.4.1.1 Location of crossing (e.g. Hwy 4 over Hwy 16)
    - 5.4.1.2 Control Section
    - 5.4.1.3 km
    - 5.4.1.4 Bridge file No.
  - 5.4.2 A summary of the governing critical elements including the following:
    - 5.4.2.1 Element description (e.g. reinforced concrete girder)
    - 5.4.2.2 Location (e.g. distance to end support)

- 5.4.2.3 Mode of failure (e.g. flexure)
- 5.4.2.4 Factored Resistance
- 5.4.2.5 Traffic category for live load (Normal Traffic or PB)
- 5.4.2.6 Lateral live load distribution
- 5.4.3 All evaluation calculations and notes including:
  - 5.4.3.1 Calculation of loads
    - 5.4.3.1.1 Dead load calculations including unit weights, member sizes, Bridge Plans used to determine bridge details, etc.
    - 5.4.3.1.2 Live load lateral distribution category
    - 5.4.3.1.3 Live load lateral distribution values used in analysis
    - 5.4.3.1.4 Dynamic load allowance
  - 5.4.3.2 Calculation of member resistances for each critical element
    - 5.4.3.2.1 Location of critical element
    - 5.4.3.2.2 Determination of material strengths
    - 5.4.3.2.3 Determination of member sizes and cross-sectional properties
    - 5.4.3.2.4 Determination of mechanical properties
  - 5.4.3.3 Determination of load factors
    - 5.4.3.3.1 System behaviour
    - 5.4.3.3.2 Element behaviour
    - 5.4.3.3.3 Inspection level
    - 5.4.3.3.4 Target Reliability Index
  - 5.4.3.4 Software analysis
    - 5.4.3.4.1 Type of software

- 5.4.3.4.2 Data inputs
- 5.4.3.4.3 Outputs
- 5.4.3.4.4 Assumptions
- 5.4.3.4.5 Constraints
- 5.4.3.4.6 Steps involved for the evaluation process
- 5.4.3.5 Calculation of Live Load Capacity Factor,  $F$  for each vehicle configuration
- 5.4.3.6 Redesign of any deficient members
- 5.4.3.7 Re-evaluation of redesigned members
- 5.5 Evaluations as Part of a Bridge Strengthening Study
  - 5.5.1 A bridge description including the following:
    - 5.5.1.1 Location of crossing (e.g. Hwy 4 over Hwy 16)
    - 5.5.1.2 Control Section
    - 5.5.1.3 km
    - 5.5.1.4 Bridge file no.
  - 5.5.2 A summary of the governing critical elements including the following:
    - 5.5.2.1 Element description (e.g. reinforced concrete girder)
    - 5.5.2.2 Location (e.g. distance from end support)
    - 5.5.2.3 Mode of failure (e.g. flexure)
    - 5.5.2.4 Factored Resistance
    - 5.5.2.5 Lateral live load distribution
  - 5.5.3 All evaluation calculations and notes including:
    - 5.5.3.1 Calculation of loads

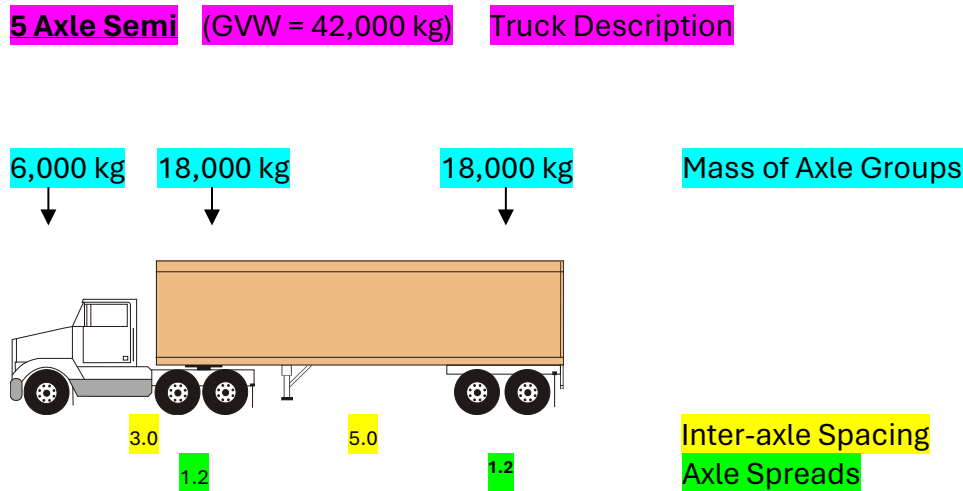
- 5.5.3.1.1 Dead load calculations including unit weights, member sizes, Bridge Plans used to determine bridge details, etc.
- 5.5.3.1.2 Live load lateral distribution category
- 5.5.3.1.3 Live load lateral distribution values used in analysis
- 5.5.3.1.4 Dynamic load allowance
- 5.5.3.2 Calculation of non-strengthened member resistances for each critical element
  - 5.5.3.2.1 Location of critical element
  - 5.5.3.2.2 Determination of material strengths
  - 5.5.3.2.3 Determination of member sizes and cross-sectional properties
  - 5.5.3.2.4 Determination of mechanical properties
  - 5.5.3.2.5 Capacity reductions due to condition
- 5.5.3.3 Determination of load factors
  - 5.5.3.3.1 System behaviour
  - 5.5.3.3.2 Element behaviour
  - 5.5.3.3.3 Inspection level
  - 5.5.3.3.4 Target Reliability Index
- 5.5.3.4 Software analysis
  - 5.5.3.4.1 Type of software
  - 5.5.3.4.2 Data inputs
  - 5.5.3.4.3 Outputs
  - 5.5.3.4.4 Assumptions
  - 5.5.3.4.5 Constraints
  - 5.5.3.4.6 Steps involved for the evaluation process

- 5.5.3.5 Summary of critical elements deficient for legal load if not on a Primary Highway (Secondary or Municipal Highways)
- 5.5.3.6 Calculation of target capacities for strengthening of deficient members
- 5.5.3.7 Summary of target capacities for strengthening of deficient members
- 5.5.4 Load limits for Permit-Single Trip (PS) vehicle configurations with deficient members strengthened to target capacity providing the documentation described above
- 5.5.5 Life cycle costs of strengthening options vs. bridge replacement

## APPENDICES

## APPENDIX A – Evaluation Truck Configurations

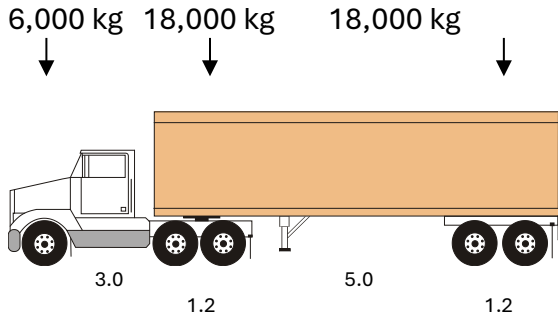
- Figure BE-1 – Typical Normal Traffic vehicle configurations for use on Primary Highways
- Figure BE-1A – Typical Normal Traffic vehicle configurations for use on Secondary Highways
- Figure BE-1B – Typical Normal Traffic vehicle configurations for use on Municipal Roads
- Figure BE-2 – Typical Permit – Single Trip (PS) vehicle configurations
- Figure BE-2A – Typical Permit – Single Trip (PS) vehicle configurations for evaluation of elements with a short influence lines
- Figure BE-3 – Typical Permit – Bulk Haul (PB) vehicle configurations
- Figure BE-3A – Permit – Bulk Haul (PB) vehicle configurations for evaluation of new designs
- Figure BE-4 – Typical Permit - Controlled (PC) axle configurations
- Figure BE-5 – Typical wheel line configuration



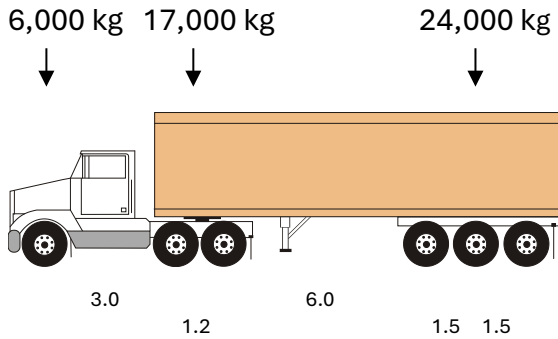
### Key to Evaluation Truck Configuration Diagrams



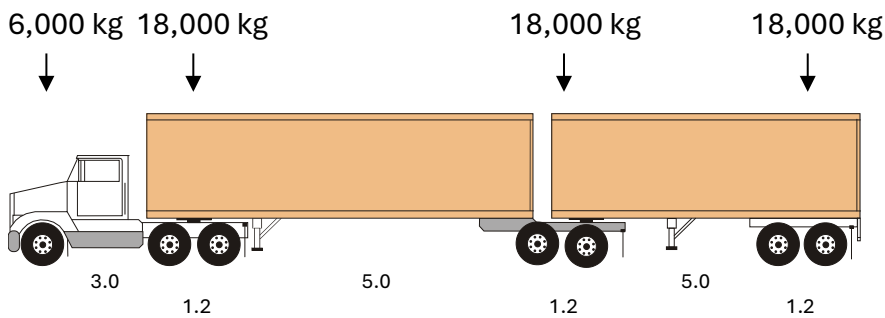
**5 Axle Semi** (GVW = 42,000 kg)



**6 Axle Semi** (GVW = 47,000 kg)



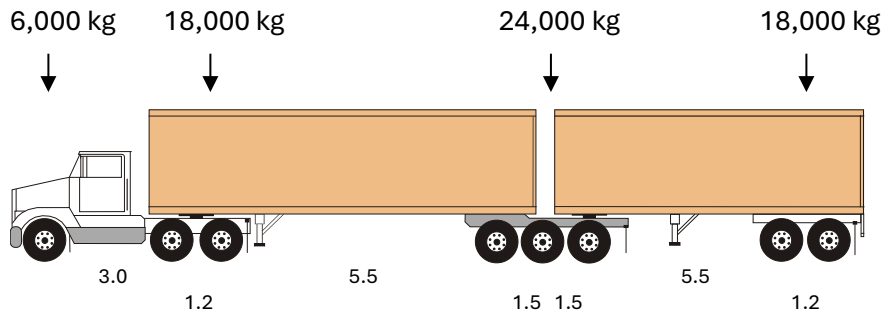
**7 Axle Train** (GVW = 60,000 kg)



**FIGURE BE-1: Typical Normal Traffic Vehicle Configurations for use on Primary Highways**

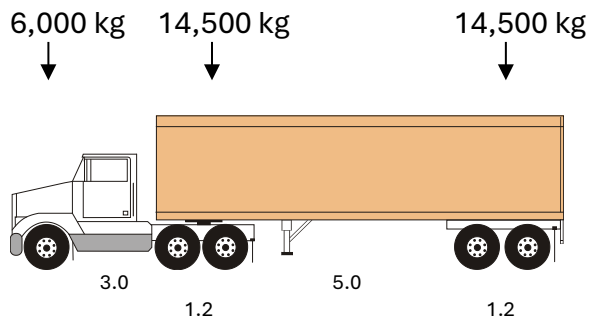
(Continued on next page)

**8 Axle Train** (GVW = 63,500 kg)

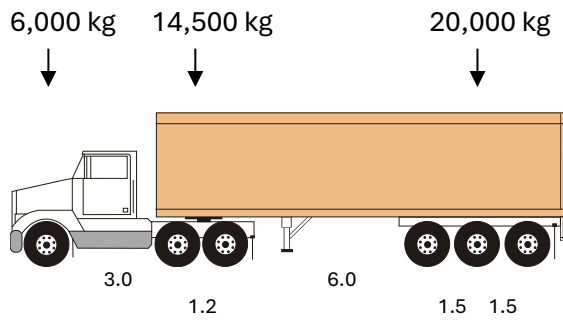


**FIGURE BE-1 (Continued): Typical Normal Traffic Vehicle Configurations for use on Primary Highways**

**5 Axle Semi** (GVW = 35,000 kg)



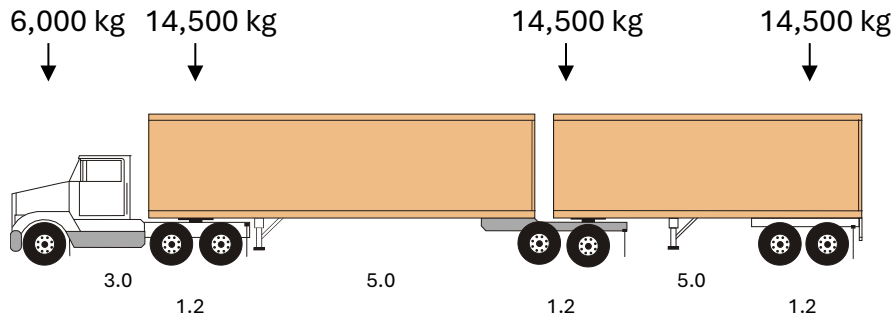
**6 Axle Semi** (GVW = 40,500 kg)



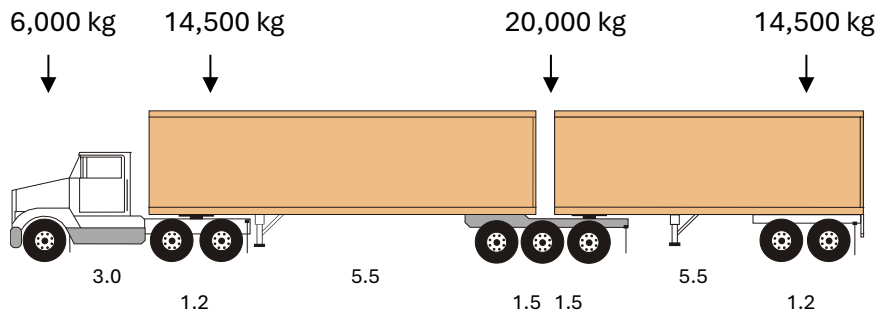
**FIGURE BE-1A: Typical Normal Traffic Vehicle Configurations for use on Secondary Highways**

Continued on next page.

**7 Axle Train** (GVW = 49,500 kg)

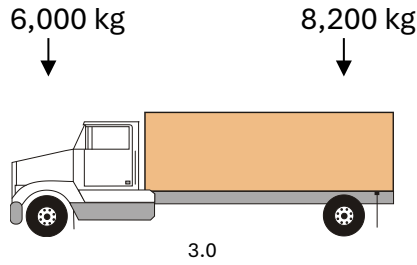


**8 Axle Train** (GVW = 54,500 kg)

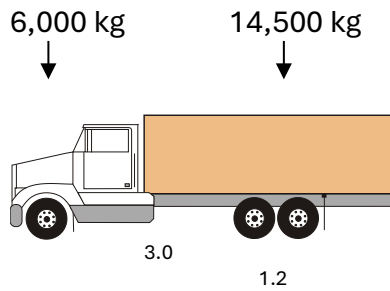


**FIGURE BE-1A (Continued): Typical Normal Traffic Vehicle Configurations for use on Secondary Highways**

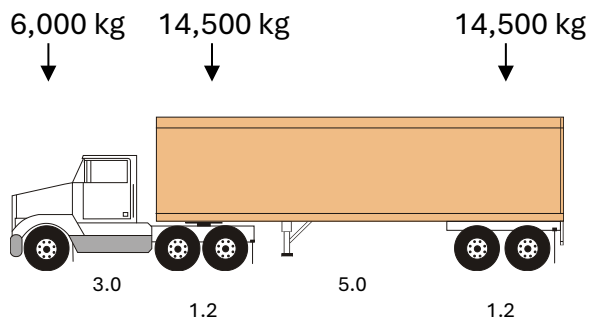
**2 Axle Truck** (GVW = 14,200 kg)



**3 Axle Truck** (GVW = 20,500 kg)



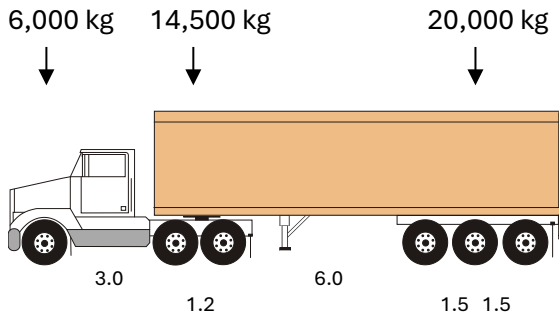
**5 Axle Semi** (GVW = 35,000 kg)



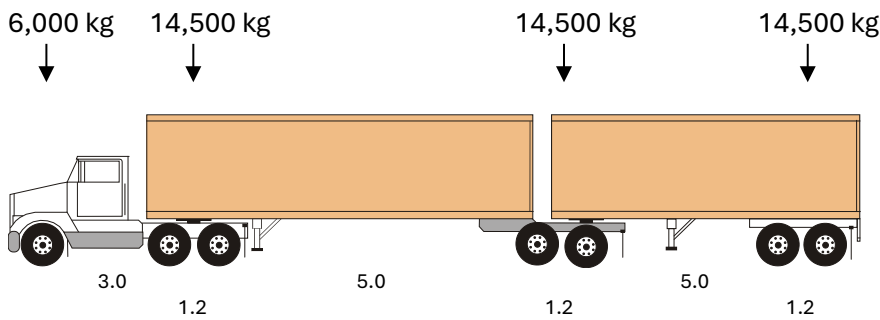
**FIGURE BE-1B: Typical Normal Traffic Vehicle Configurations for use on Municipal Highways**

Continued on next page.

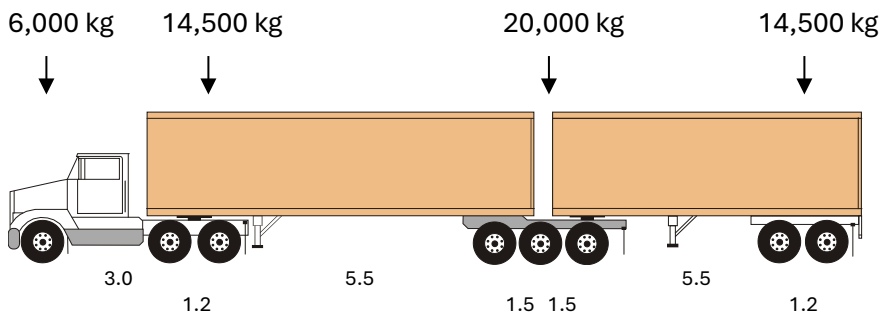
**6 Axle Semi** (GVW = 40,500 kg)



**7 Axle Train** (GVW = 49,500 kg)

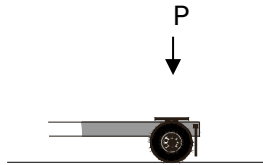


**8 Axle Train** (GVW = 54,500 kg)

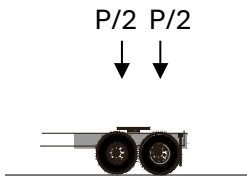


**FIGURE BE-1B (Continued): Typical Normal Traffic Vehicle Configurations for use on Municipal Highways**

**Single**

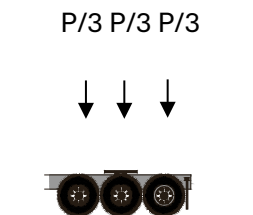


**Tandem**



1.2

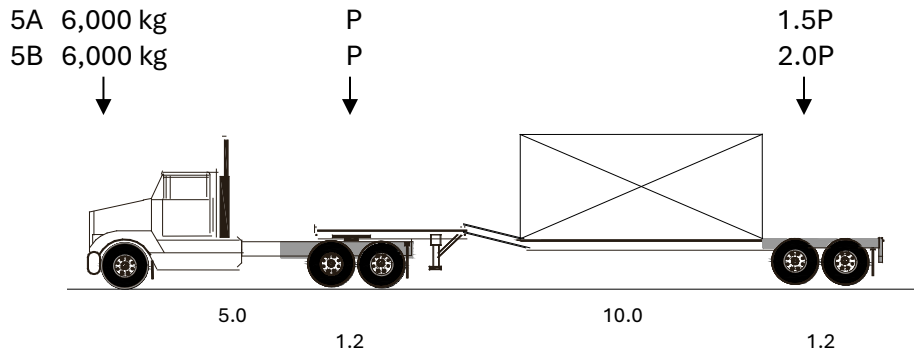
**Tridem**



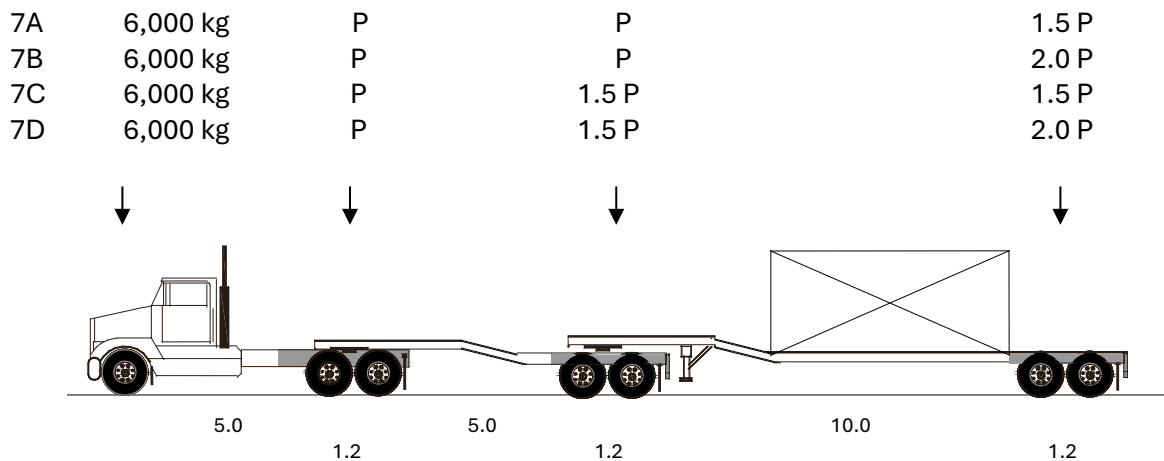
1.5 1.5

**FIGURE BE-2: Typical Permit - Single Trip (PS) Vehicle Configurations**

**5 Axle PS Trucks**



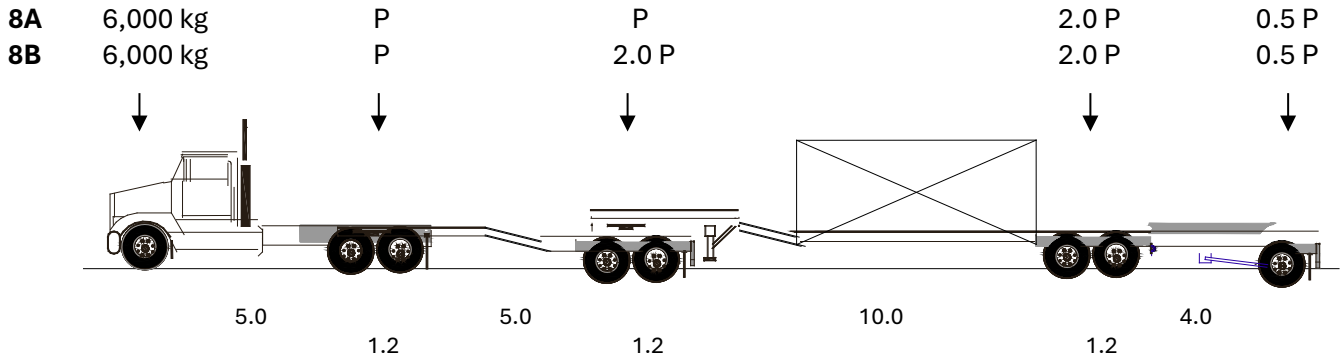
**7 Axle PS Trucks**



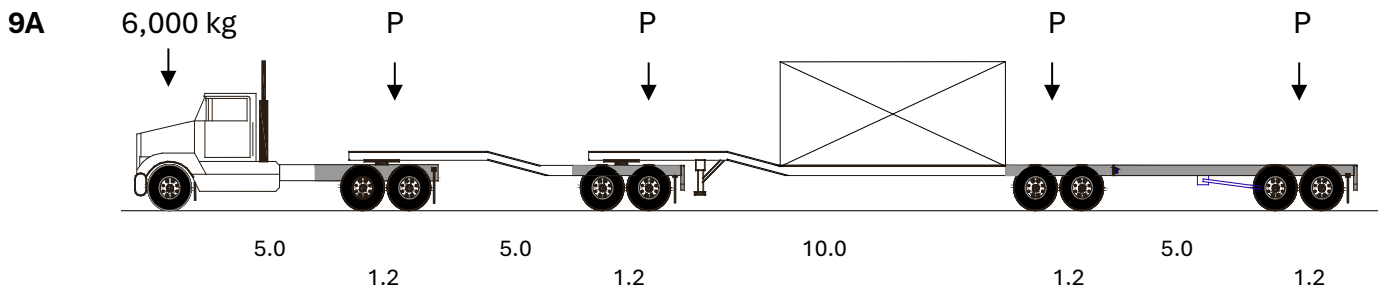
**FIGURE BE-2 (Continued): Typical Permit - Single Trip (PS) Vehicle Configurations**

(Continued on next page)

**8 Axle PS Truck**

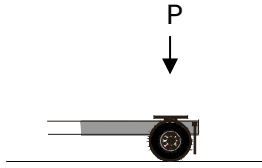


**9 Axle PS Truck**

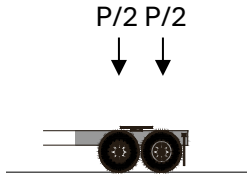


**FIGURE BE-2 (Continued): Typical Permit - Single Trip (PS) Vehicle Configurations**

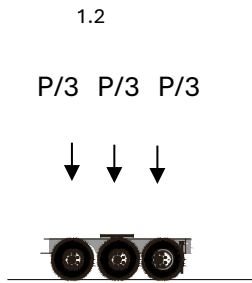
**Single**



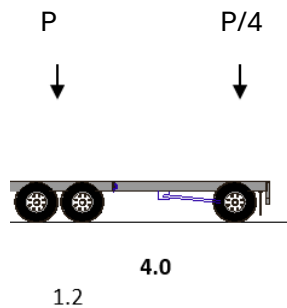
**Tandem**



**Tridem**



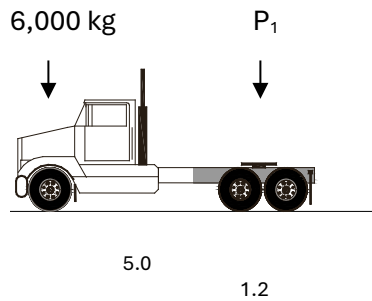
**Tandem and Booster**



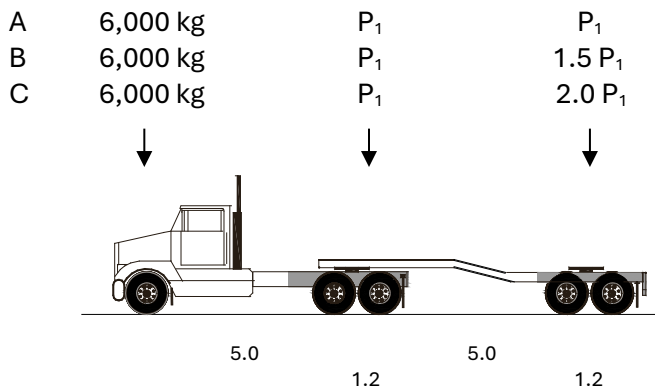
**FIGURE BE-2A: Typical Permit - Single Trip (PS) Vehicle Configurations for Evaluation of Short Influence Line Bridges**

(Continued on next page)

**Tractor**



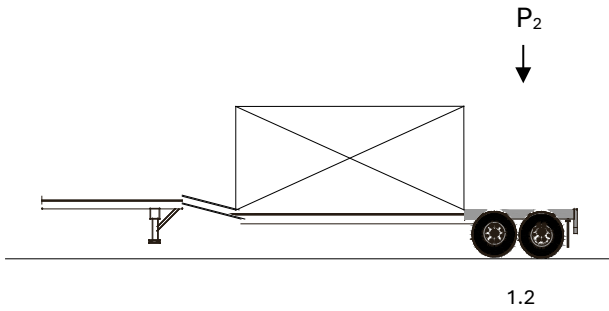
**Tractor + Jeep**



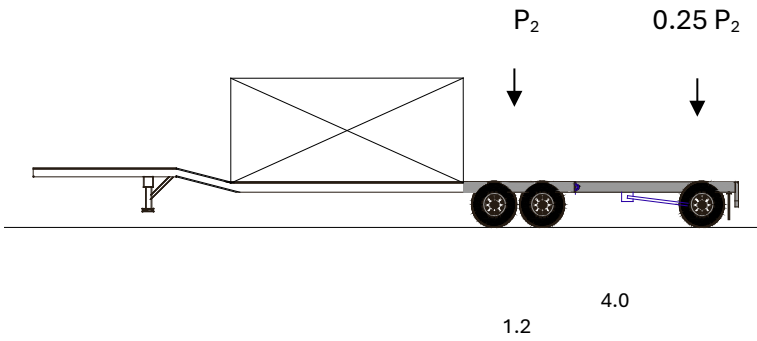
**FIGURE BE-2A (Continued): Typical Permit - Single Trip (PS) Vehicle Configurations for Evaluation of Short Influence Line Bridges**

(Continued on next page)

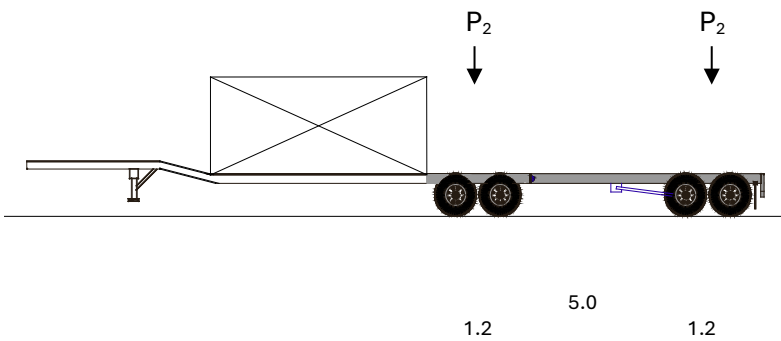
**Trailer**



**Trailer + Single Booster**

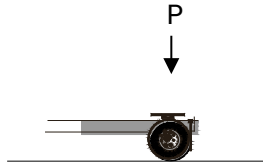


**Trailer + Tandem Booster**

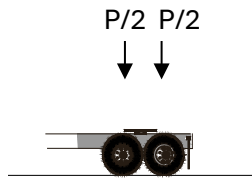


**FIGURE BE-2A (Continued): Typical Permit - Single Trip (PS) Vehicle Configurations for Evaluation of Short Influence Line Bridges**

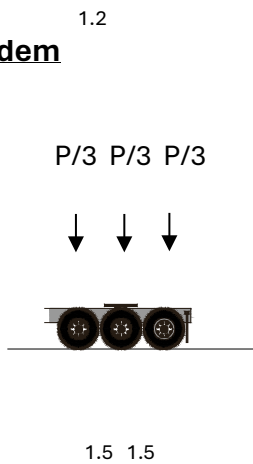
**Single**



**Tandem**



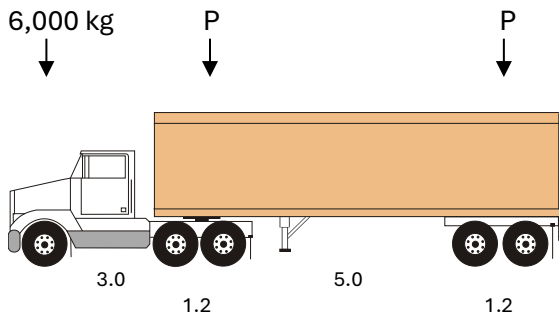
**Tridem**



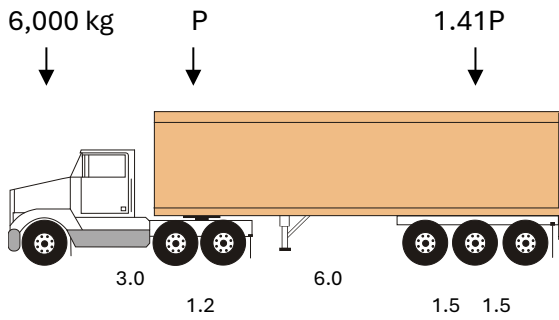
**FIGURE BE-3: Typical Permit – Bulk Haul Vehicle Configurations**

(Continued on next page)

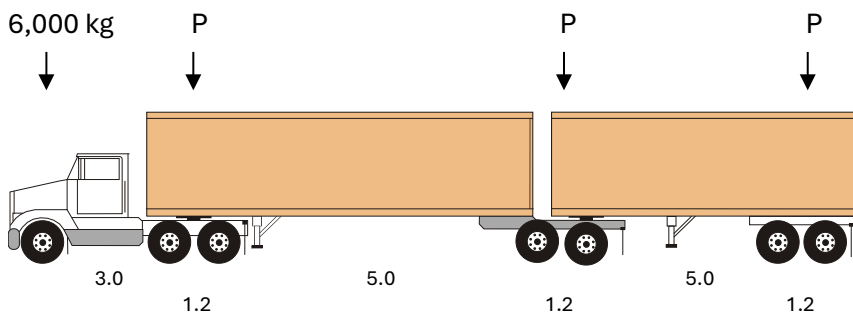
**5 Axle Semi**



**6 Axle Semi**



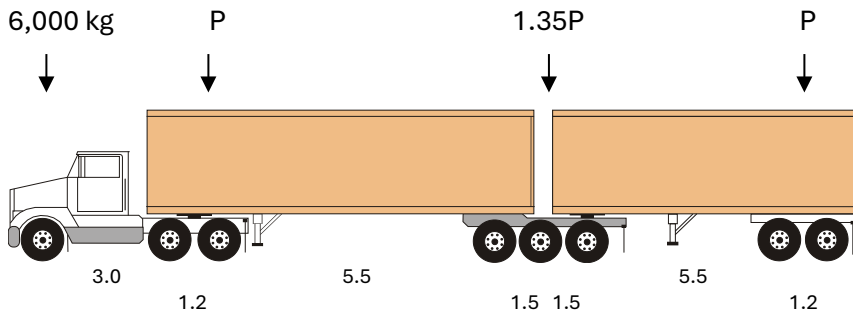
**7 Axle Train**



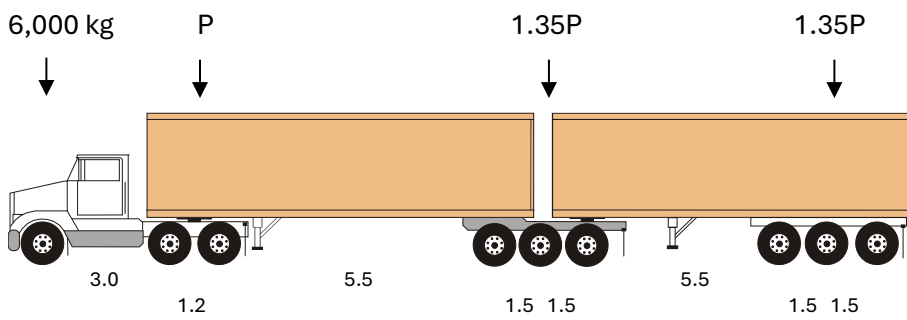
**FIGURE BE-3 (Continued): Typical Permit – Bulk Haul Vehicle Configurations**

(Continued on next page)

**8 Axle Train**

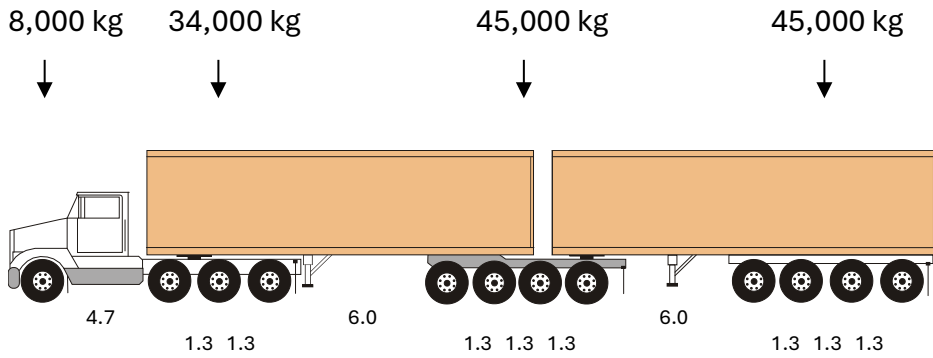


**9 Axle Train**

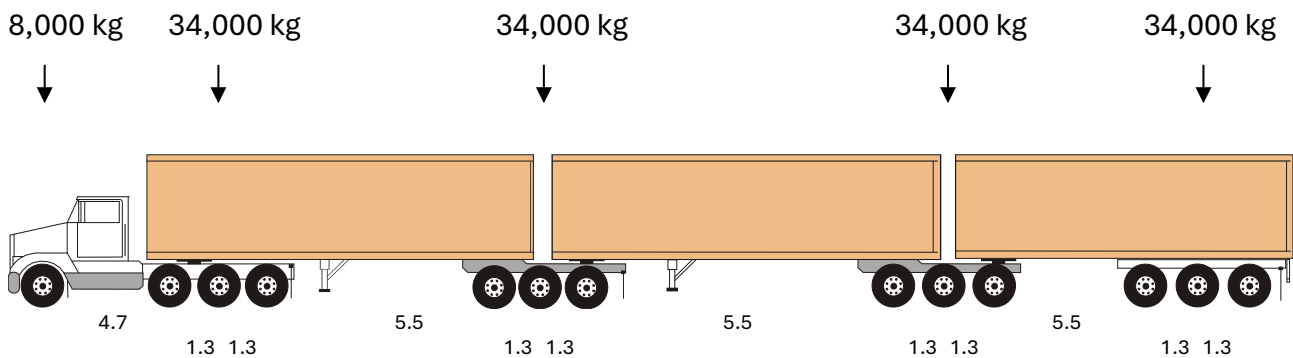


**FIGURE BE-3 (Continued) : Typical Permit – Bulk Haul Vehicle Configurations**

**PB Truck 1 (132,000 kg GVW)**



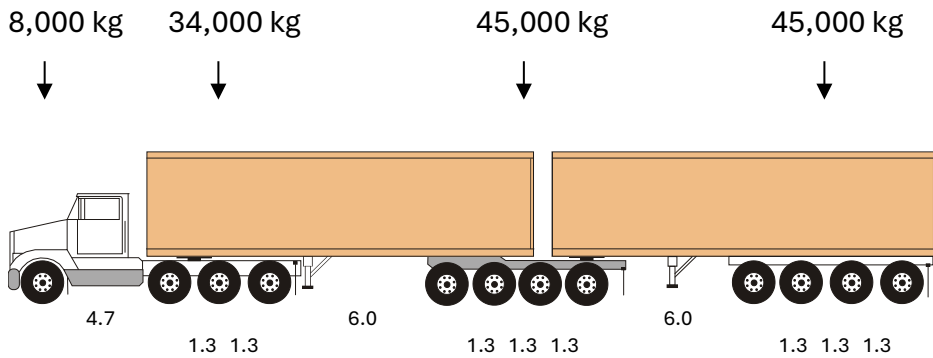
**PB Truck 2 (144,000 kg GVW)**



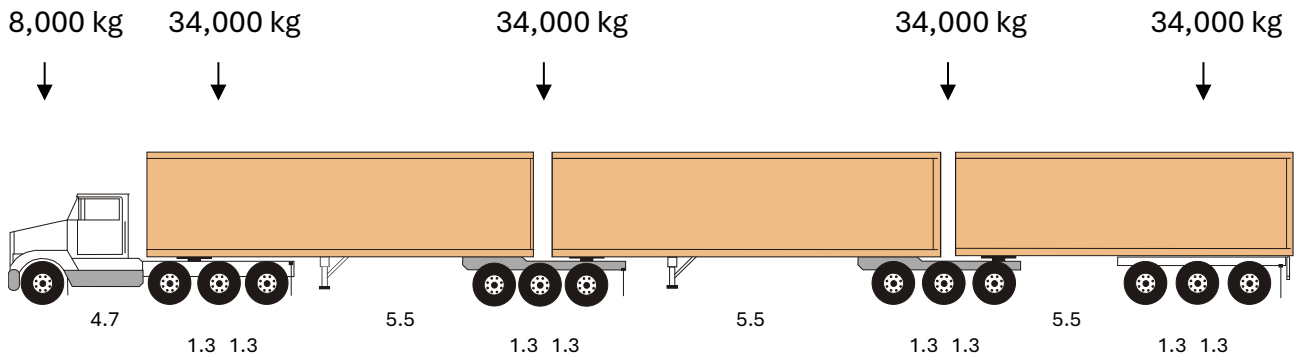
Note: Trailer axles will likely be 2.6 m -2.9 m wide.

(Continued on next page)

**PB Truck 1 (132,000 kg GVW)**



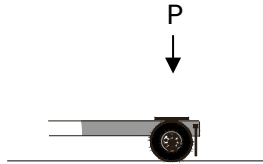
**PB Truck 2 (144,000 kg GVW)**



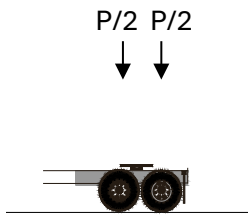
Note: Trailer axles will likely be 2.6 m -2.9 m wide.

**FIGURE BE-3A: Permit – Bulk Haul Vehicle Configurations for Evaluation of New Designs**

**Single**

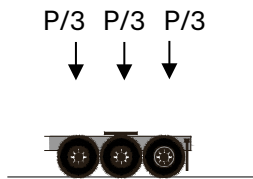


**Tandem**



1.22

**Tridem**

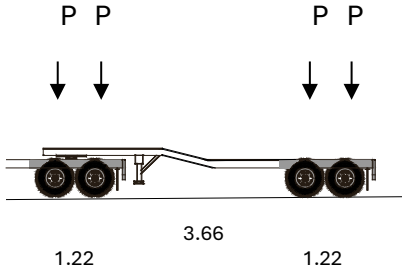


1.22 1.22

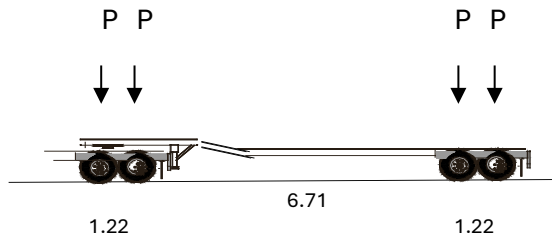
**FIGURE BE-4: Typical Permit – Controlled (PC) Axle Configurations**

(Continued on next page)

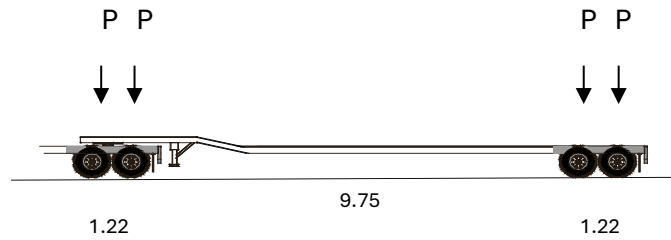
**Twin-6**



**Twin-9**



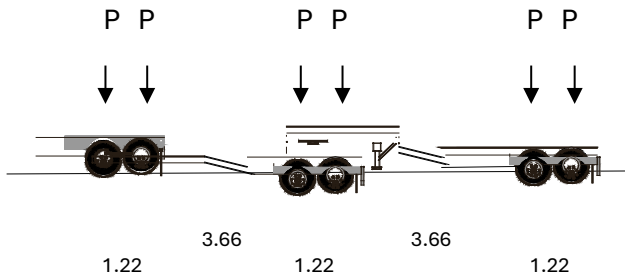
**Twin-12**



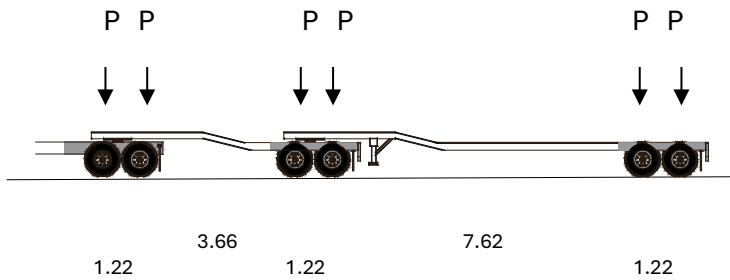
**FIGURE BE-4 (Continued): Typical Permit – Controlled (PC) Axle Configurations**

(Continued on next page)

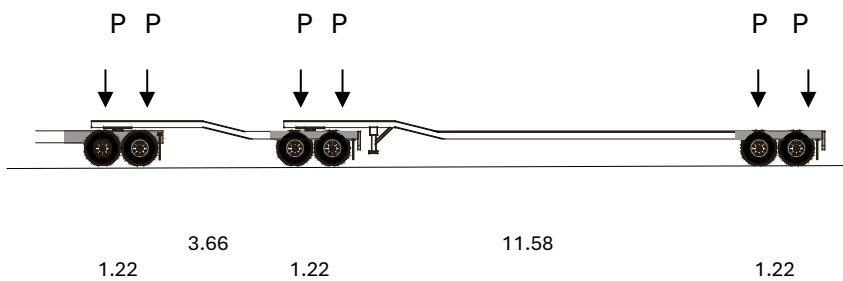
**Twin + Trail-11**



**Twin + Trail-15**



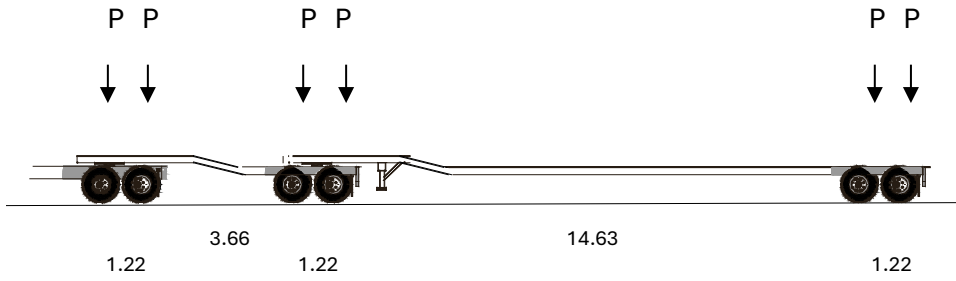
**Twin + Trail-19**



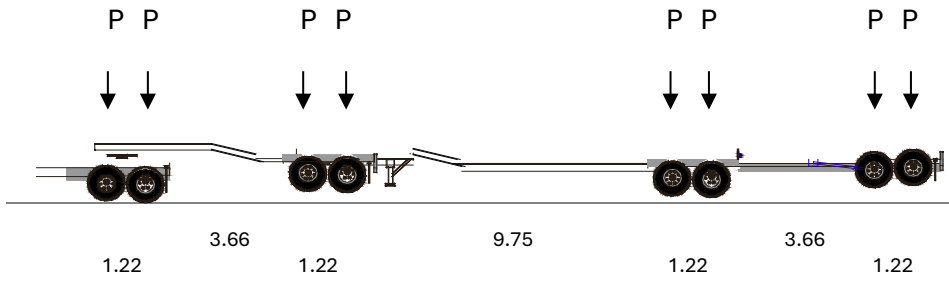
**FIGURE BE-4 (Continued): Typical Permit – Controlled (PC) Axle Configurations**

(Continued on next page)

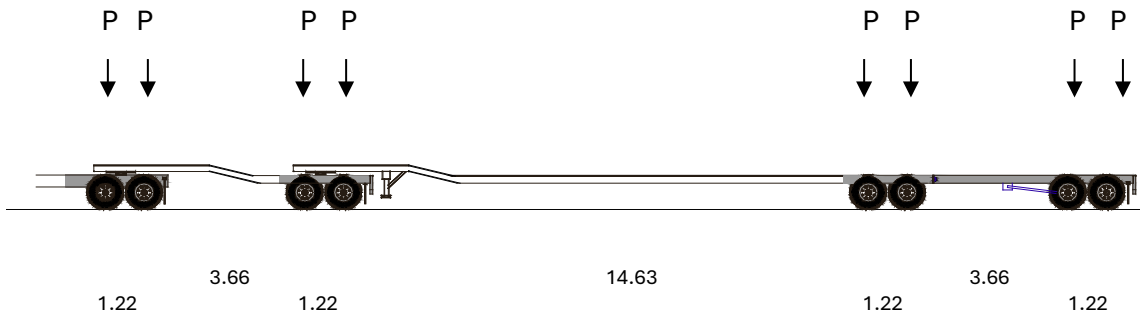
**Twin + Trail-22**



**Double Twin-22**



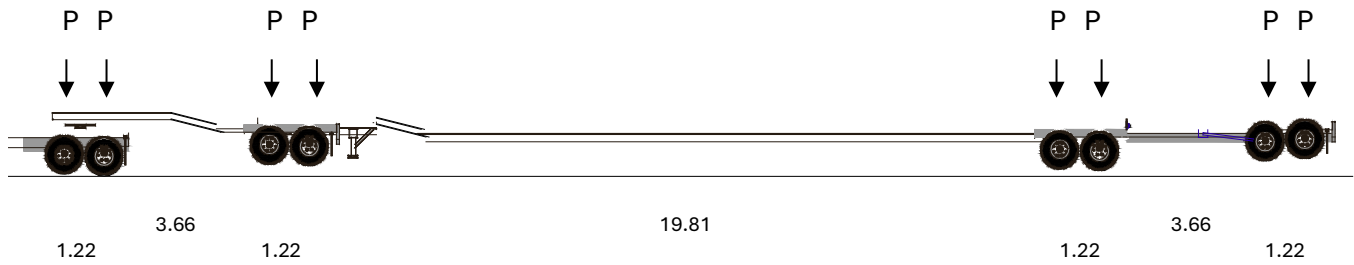
**Double Twin-27**



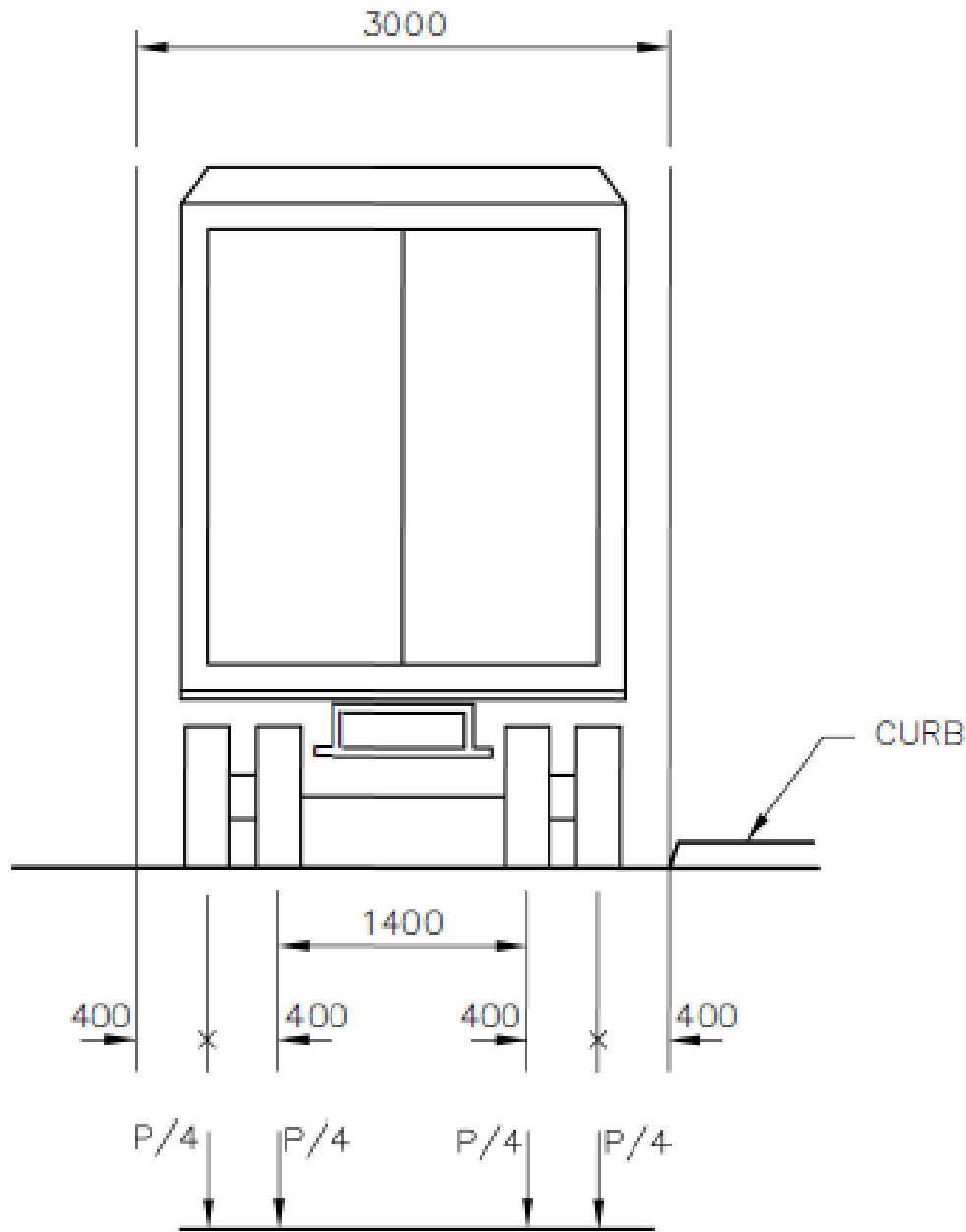
**FIGURE BE-4 (Continued): Typical Permit – Controlled (PC) Axle Configurations**

(Continued on next page)

**Double Twin-32**



**FIGURE BE-4 (Continued): Typical Permit – Controlled (PC) Axle Configurations**



**FIGURE BE-5: Typical Wheel Line Configuration**

## APPENDIX B – Load Factors

Table BE - 1 Summary of Load Factors to be used for Ministry of Highways Evaluations

**TABLE BE-1: Summary of Load Factors to be used for Ministry of Highways:**

<b>Normal Traffic Factor NP</b>									
$\beta$		2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
All analysis	All Spans		1.35	1.42	1.49	1.56	1.63	1.70	1.77

<b>Bulk Haul Factor PB</b>									
$\beta$		2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
Determinate	All Spans		1.28	1.33	1.38	1.43	1.49	1.54	1.61
Sophisticated	All Spans		1.29	1.35	1.40	1.46	1.52	1.58	1.65
Simple	All Spans		1.28	1.35	1.41	1.48	1.54	1.62	1.68

<b>Timber Haul Factors</b>									
$\beta$		2.25	2.5	2.75	3	3.25	3.5	3.75	4.00
Determinate	All Spans	1.21	1.25	1.30	1.34	1.39	1.45	1.51	
Sophisticated	All Spans	1.22	1.27	1.31	1.36	1.42	1.48	1.55	
Simplified	All Spans	1.20	1.25	1.30	1.37	1.43	1.49	1.57	

## APPENDIX C – Evaluation Aids

Table BE-2 – Reinforced Concrete Material Properties

Figure BE-6 – Load Limit Curve Template

Figure BE-7 – Load Limit Curve Template for Short Influence Line Bridges

## TABLE BE-2: Reinforced Concrete Material Properties

### A) Properties of Reinforcing Steel When Plans or Test Results are Unavailable

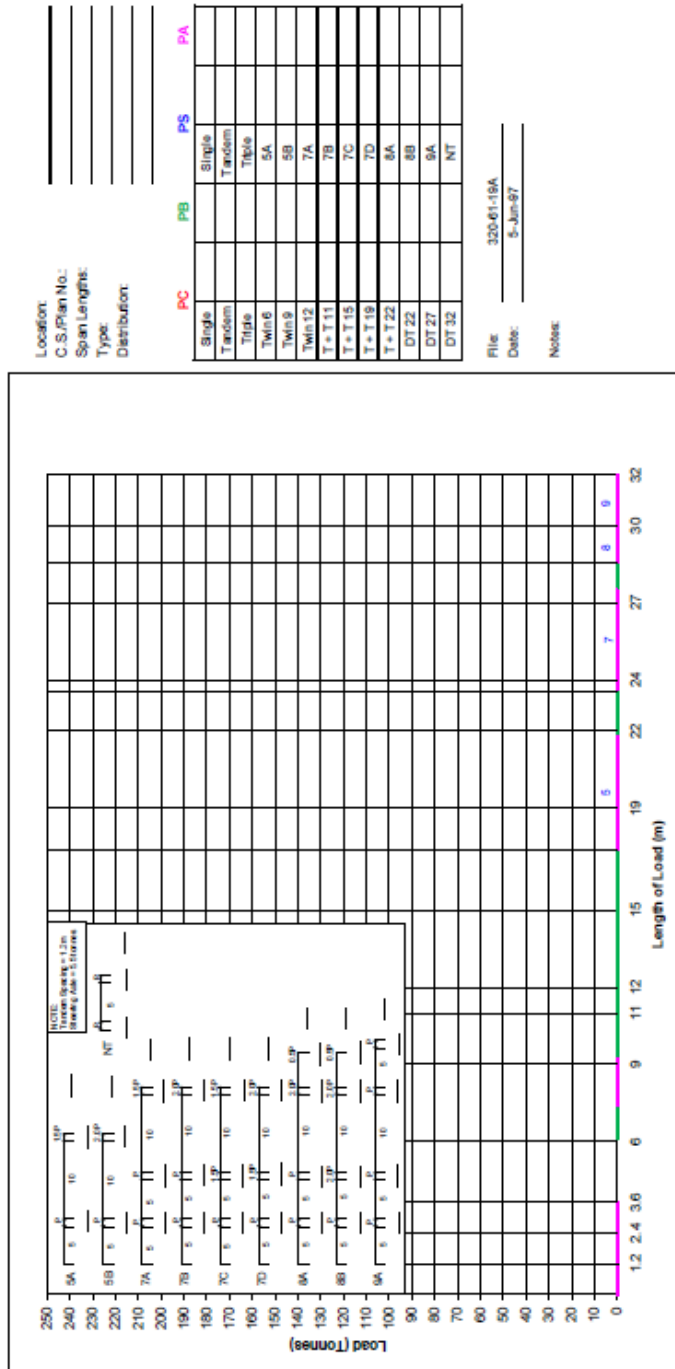
Construction Year	Specified Minimum Yield Strength, $F_y$ to be Assumed (MPa)			
	Unknown Grade	Structural Grade	Intermediate Grade	Hard Grade
Before 1914	210			
1914 - 1955	230	230	275	345
1956 - 1978	275	275	345	415
After 1978	350	300	350	400

NOTE: Assume Intermediate grade used in Saskatchewan starting 1929

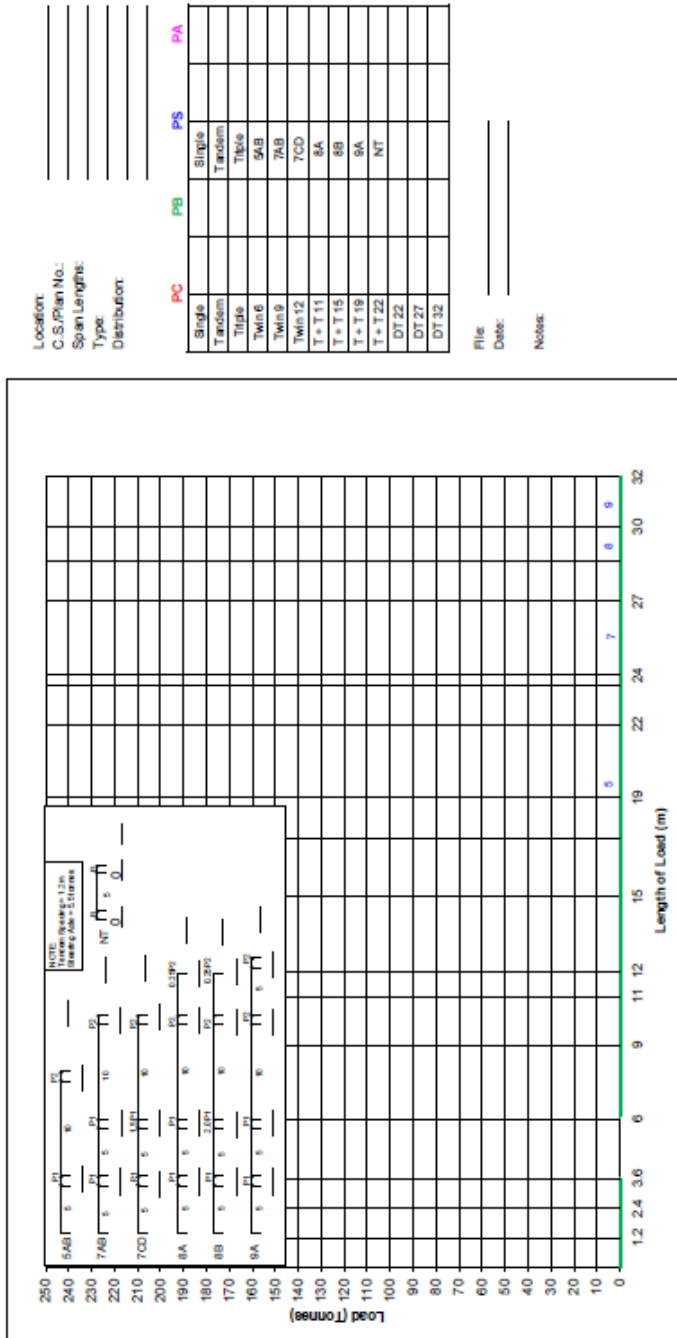
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**TABLE BE-2: Reinforced Concrete Material Properties**B) Methods of Determining the Compressive Strength of Concrete,  $f'_c$ 

	Compressive Strength of Concrete, $f'_c$	
Construction Specifications	No Visible Sign of Concrete Damage	Visible Sign of Concrete Damage
Available	The compressive strength of concrete as specified on the plans or from tests of drilled cores having a diameter of not less than 100 mm	The compressive strength of the sound concrete as specified on the plans or from tests of drilled cores. Where appropriate, small diameter cores from damaged areas may be used to determine the type and extent of deterioration. Non-destructive test methods may be used to correlate the concrete strength of the damaged zones with that of the sound concrete in the same bridge.
Not Available	20 MPa or from tests of drilled cores having a diameter of not less than 100 mm.	For sound concrete, 20 MPa or from tests of drilled cores having a diameter of not less than 100 mm. Where appropriate, small diameter cores from damaged areas may be used to determine the type and extent of deterioration. Non-destructive test methods may be used to correlate the concrete strength of the damaged zones with that of the sound concrete in the same bridge.



**FIGURE BE-6: Load Limit Curve Template**



Location: \_\_\_\_\_  
 C.S./Plan No.: \_\_\_\_\_  
 Span Lengths: \_\_\_\_\_  
 Type: \_\_\_\_\_  
 Distribution: \_\_\_\_\_

PC	PB	PS	PA
Single	Single	Single	
Tandem	Tandem	Tandem	
Triple	Triple	Triple	
Twin 6	9AB		
	7AB		
	Twin 12	7CD	
	T+T 11	8A	
	T+T 15	8B	
	T+T 19	9A	
	T+T 22	NT	
DT 22			
DT 27			
DT 32			

File: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Notes: \_\_\_\_\_

**FIGURE BE-7: Load Limit Curve Template for Short Influence Line Bridges**