# OPermit bridge structural data guide

First edition, Amendment 1, Effective from July 2017




NZ TRANSPORT AGENCY
WAKA KOTAHI

New Zealand Government

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# DOCUMENT MANAGEMENT PLAN

1) Purpose

This management plan outlines the updating procedures and contact points for the document.

2) Document information

| | |
|---|---|
| Document name | *OPermit bridge structural data guide* |
| Document number | - |
| Document availability | This document is located in electronic form on the NZ Transport Agency's website at www.nzta.govt.nz. |
| Document owner | National Structures Manager |
| Document sponsor | National Manager Professional Services |
| Prepared by | Professional Services, NZ Transport Agency |

3) Amendments and review strategy

All corrective action/improvement requests (CAIRs) suggesting changes will be acknowledged by the document owner.

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|---|---|---|
| Amendments (minor revisions) | Updates to be notified to users by publication of a technical memorandum placed on the NZ Transport Agency's website. | As required. |
| Review (major revisions) | Periodic updates will be undertaken where amendments fundamentally changing the content or structure of the manual or new technology resulting from research or ongoing refinement have been identified. | As required. |
| Notifications | All users that have registered their interest by email to hip.feedback@nzta.govt.nz will be advised by email of amendments and updates. | Immediately. |

4) Distribution of this management plan

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# RECORD OF AMENDMENTS

This document is subject to review and amendment from time to time. Amendments will be recorded in the table below.

Changes since the previous amendment are indicated by a vertical line in the margin. The date of issue or amendment of a page appears in the footer on each page. This page will be updated each time a new amendment is released.

| Amendment number | Description of change | Effective date | Updated by |
|---|---|---|---|
| 0 | *OPermit bridge structural data guide* 1st edition published. | April 2016 | Nigel Lloyd |
| 1 | Minor clarifications to clauses 4.4.2 and 4.6.<br>Recommendations for specific cases added to in clause 5.4.6.<br>Definitions for Bstd and Bcentre amended in table 5.7.1. | July 2017 | Nigel Lloyd |
| | | | |

## Contents

# 1 INTRODUCTION

## 1.1 Purpose

The *OPermit bridge structural data guide* provides guidance for:

- the development of structural data for bridges and major culverts in the OPermit overweight permit checking system
- the engineering principles underpinning the structural analysis methods of OPermit
- the interpretation of OPermit output.

This document is intended for personnel providing bridge technical support to Permit Issuing Officers (PIOs) and for personnel who create and maintain OPermit structural data.

## 1.2 Structure of this document

Section 2 'OPermit system overview' provides an overview of the OPermit system, its operation and data management.

Section 3 'OPermit bridge representation' provides guidance on the various structural elements used by OPermit to represent bridges.

Section 4 'OPermit analysis' describes the technical principles adopted for the structural checking of bridges for overweight vehicles.

Section 5 'Bridge data evaluation' describes the specific evaluation of data for each of the bridge elements.

The references and appendices provide additional information.

# 2 OPERMIT SYSTEM OVERVIEW

## 2.1 OPermit system

The OPermit system is used for the routine processing of permits for overweight vehicles. The checking process for bridges involves some structural analysis. The effects of vehicles on bridges are compared directly with the capacities of the bridge components. Structural capacity information is stored for all the bridges on the network. Any restriction or supervision requirement is reported. Additional output showing the structural effects of vehicles on specific bridges is available.

The system also provides a means of checking for compliance with the NZ Transport Agency's policy for overweight permits.

## 2.2 Policy for overweight permits

The overweight policy covers the issue of permits for vehicles that exceed the legal mass limits defined in the Vehicle Dimensions and Mass Rule. Permits are not available for the transportation of divisible loads that can practically be reduced in size, such as gravel or logs.

The legal mass limits represent the maximum masses that can be sustained under normal conditions without undue deterioration of the road network facilities. Although there is no established right to exceed the legal mass limits, it is recognised that some loads cannot practically be reduced. Such loads can be allowed if all facilities on the route are carefully checked when exemption is sought. Restrictions may be imposed on the conditions for travel.

This policy contains detailed procedures for determining the conditions under which a permit may be issued. It has been developed in part to protect road network facilities from loadings that may lead to premature structural deterioration.

Bridges impose a finite limit on the maximum masses that can be carried on any particular route. By carefully classifying the strength of road bridges, the policy allows maximum use of these facilities without undue damage or deterioration.

The *Vehicle dimension and mass permitting manual* (published July 2015) provides supporting information for the overweight policy.

## 2.3 Overweight permit process

Permit applications are made by operators of overweight vehicles to the Transport Agency or the local authority.

NZ Transport Agency regional managers have the authority to issue permits for movements of overweight vehicles on state highways. Where a movement involves both state highways and local authority roads, Transport Agency managers have the authority to issue a permit for the full journey, provided that each local authority is a party to the policy and approves travel for its roads. Local authorities, whether a party to the policy or not, are responsible for considering requests for and have the authority to issue permits for the movement of overweight vehicles on roads (excluding state highways) within their local authority area.

Permit Issuing Officers (PIOs) manage the processing of the applications using OPermit, and arrange the preparation of permits. Should bridge capacity queries arise during the processing, PIOs contact the nominated personnel responsible for the bridge structures.

## 2.4 Maintaining OPermit bridge data

Bridge data is held in the Bridge Database System (BDS). The BDS is a database separate from OPermit, but is accessed by OPermit to allow the structural checking of bridges.

It is important that whenever a new bridge or major culvert is constructed, or whenever existing structures are widened/replaced or their capacities are changed through deterioration, strengthening or repairs, the BDS must be updated. The success of OPermit is critically dependent on the quality of the data in the BDS.

## 2.5 OPermit analysis output

Refer to appendix D for a description of OPermit structural analysis outputs.

# 3 OPERMIT BRIDGE REPRESENTATION

## 3.1 Bridge information requirements

Figure 3.1 illustrates schematically the information requirements for OPermit operation, including the bridge data (shown in the grey box).

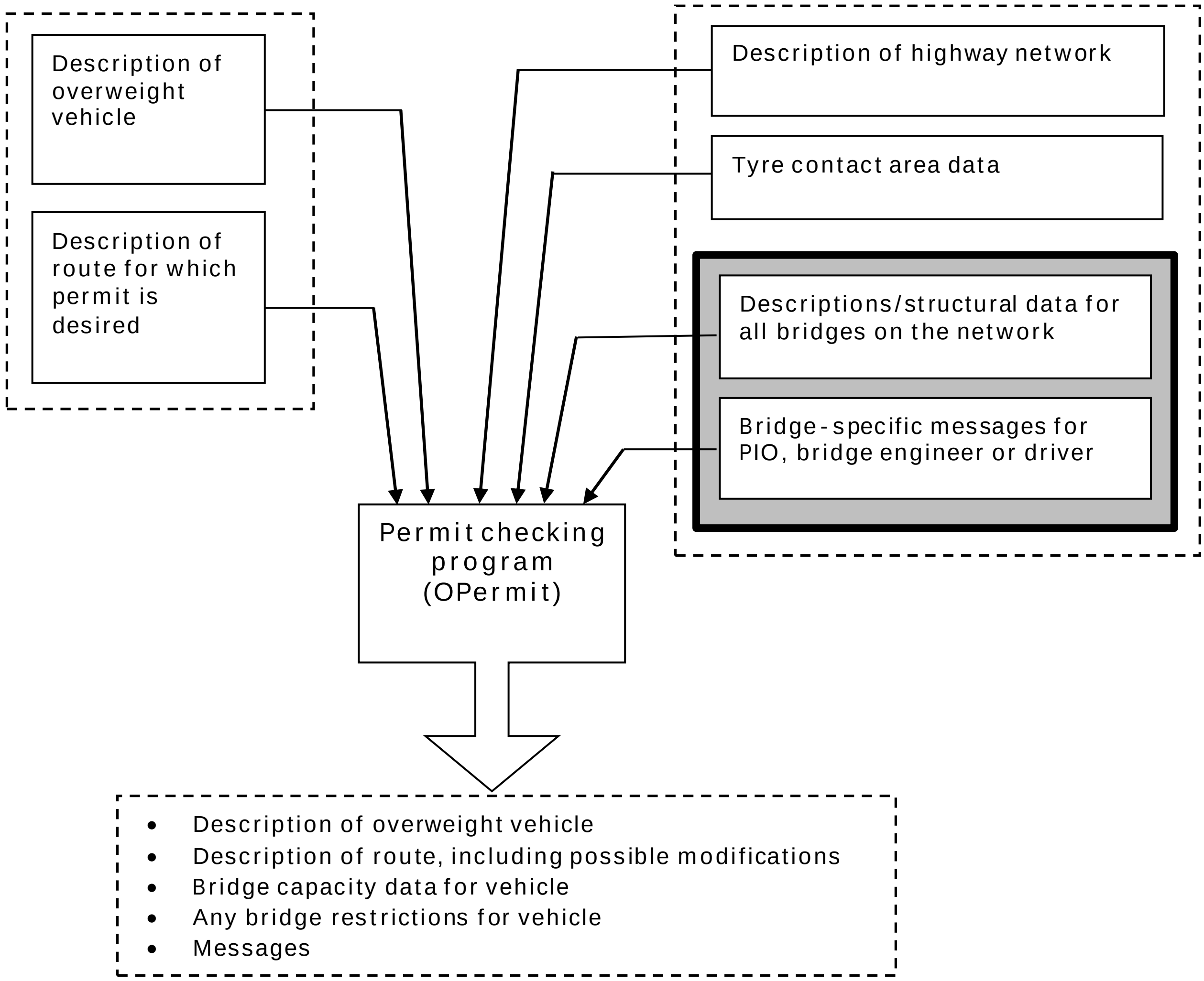



Figure 3.1: Information requirements for OPermit operation

## 3.2 Structures to be included

All bridges and culverts (with a waterway area ≥ $3.4m^2$) shall be included, except that under the following condition, culverts may be excluded subject to confirmation that they will not be critical for overweight vehicles. Culverts that may be excluded will:

- have a span of less than 2m, and
- have more than 1m of fill above, and
- be undamaged, and
- there will be no unusual circumstances (eg Posted structure).

# 3.3 Bridge representation

## 3.3.1 GENERAL

Each bridge/culvert is described by the GENERAL bridge data and is further represented by at least one of the underlying element types (BEAM, VBEAM, DECKSLAB, etc), which contain specific information about each element of the structure.

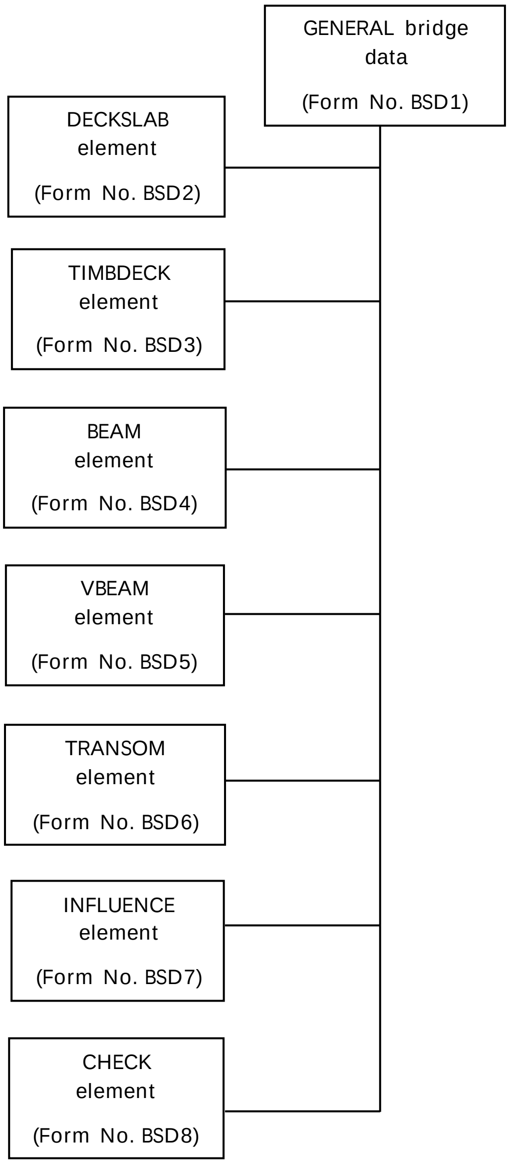



Figure 3.2: Bridge data structure

Descriptions of each element type are given in table 3.1.

Table 3.1: Element descriptions

| Element | Description |
|---|---|
| GENERAL | General Information about the structure, including name, location, carriageway, width, etc. This element is required for all structures. |
| DECKSLAB | Used to model reinforced concrete deck slabs. |
| TIMBDECK | Used to model timber decks. |
| BEAM | Used to model longitudinal components (as an equivalent simply supported span), such as main beams, stringers or trusses, where the components are of similar capacity and evenly spaced. |
| VBEAM | Similar to BEAM elements but used where beams are asymmetrically spaced, are of differing capacities or there are discontinuities in the structure cross-section. |
| TRANSOM | Used to represent transoms (transverse members). |
| INFLUENCE | For critical components (where other elements are unsuitable), the overload effects are determined from influence lines. |
| CHECK | CHECK elements comprise comments or instructions, and are used to augment structure data or outline specific actions required as part of the overweight permit process. Different CHECK elements may be used to inform Permit Issuing Officers (PIOs), bridge engineers or vehicle drivers. |

### 3.3.2 GENERAL bridge data

A GENERAL ELEMENT DATA form (Form No. BSD1 – see appendix A) must be completed for every new structure.

Refer to section 5.1 for detailed guidance on completing the form.

### 3.3.3 Bridge element data

Critical structural components of a bridge can be modelled using any of seven element types. There is an element data form for each element type (Form Nos. BSD2 to BSD8 – see appendix A).

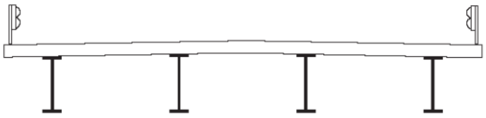
Refer to sections 5.2 to 5.8 for detailed guidance on completing the element data forms.

The various bridge element types allow for the structural modelling of different bridge types. The designer must determine which element types are required to fully model the effects of overweight vehicles on the structure. More than one element type will usually be required to adequately represent a structure. Section 3.3.4 provides guidance on the element types that are usually required to represent typical bridge configurations.

### 3.3.4 Elements required for typical bridge configurations

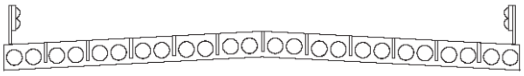
The first step in adding new records to the BDS is to determine how the structure is to be represented, ie what element data is required to best model the structure.

Suggestions for how different typical bridge types can be modelled using the various element types are given in figure 3.3 below. It must be emphasised that there is freedom to use the most appropriate element types and this will vary for different bridge types and critical member configurations. Each element is described further in section 5.



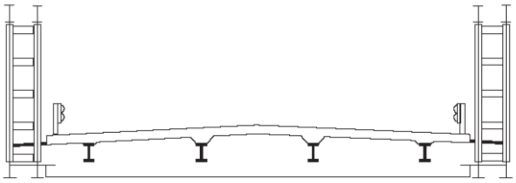
Type: Beam and Slab Bridge

| Component | Element |
|---|---|
| Deck | DECKSLAB |
| Beams | BEAM |



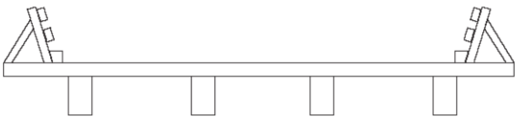
Type: Double Hollow Core Beam Bridge

| Component | Element |
|---|---|
| Hollow core beams | BEAM |



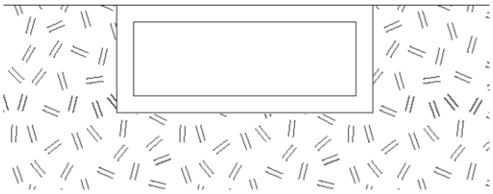
Type: Truss Bridge

| Component | Element |
|---|---|
| Trusses | BEAM |
| Transom | TRANSOM |
| Stringers | BEAM |
| Deck | DECKSLAB |



Type: Timber Bridge

| Component | Element |
|---|---|
| Deck | TIMBDECK for interior spans INFLUENCE for cantilever spans or use CHECK 3 to keep vehicle off cantilever spans. eg 'Vehicle to be greater than 0.5m from kerb'. |
| Beams | BEAM |

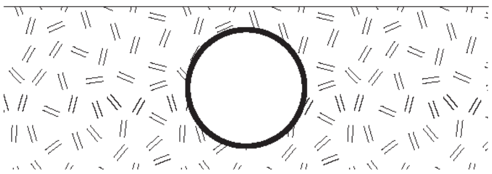


Type: Concrete Box Culvert

| Component | Element |
|---|---|
| Reinforced concrete box | BEAM |
| Deck | DECKSLAB |

- Model as 'Single lane bridge' with capacity and dimensions based on 3.5m barrel length
- Estd = Ecentre = 1.0
- Width defined as 3.5m in General Element Data

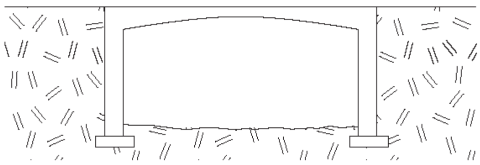
Figure 3.3: Element types for typical bridges



Type: Metal or Concrete Pipe Culvert

| Component | Element |
|---|---|
| Pipe | BEAM |

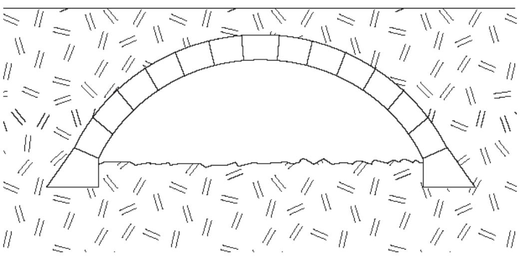
- Model as 'Single lane bridge' with capacity and dimensions based on 3.5m barrel length
- Estd = Ecentre = 1.0
- Model as span = diameter with MCAP and SCAP commensurate with pipe capacity
- Width defined as 3.5m in General Element Data



Type: Slab Bridge

| Component | Element |
|---|---|
| Top slab & walls | BEAM |
| Deck | DECKSLAB |

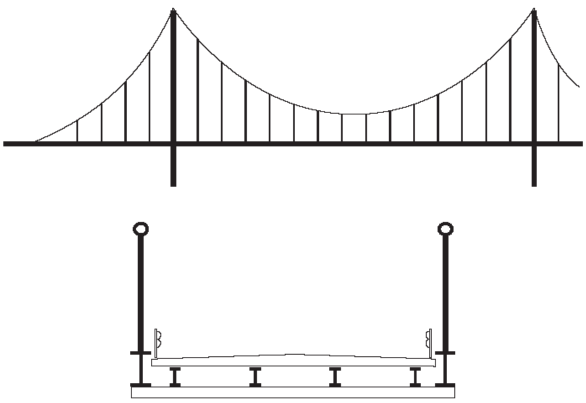
- For short spans (eg <10m), model as 'Single lane bridge' with capacity and dimensions based on 3.5m width
- Estd = Ecentre = 1.0
- Width defined as 3.5m in General Element Data



Type: Arch (span < 10m)

| Component | Element |
|---|---|
| Arch | BEAM or INFLUENCE* |

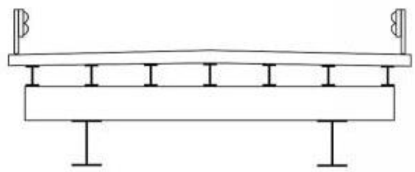
- Model as 'Single lane bridge' with capacity and dimensions based on 3.5m barrel length
- Estd = Ecentre = 1.0
- *Use INFLUENCE if there is a specific weak structural location



Type: Suspension Bridge

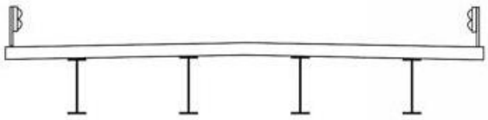
| Component | Element |
|---|---|
| Deck | DECKSLAB |
| Stringers | BEAM |
| Transoms | TRANSOM |
| Distribution beams | INFLUENCE |
| Hangers | INFLUENCE |
| Cables | CHECK 1 'Max Gross Weight - Unrestricted = 42 tonnes, - Restricted (crawl central) = 50 tonnes' CHECK 3 eg 'No other heavy vehicles on bridge' |

Figure 3.3: Element types for typical bridges (continued)



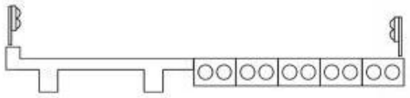
Type: Cantilevered Transoms

| Component | Element |
|---|---|
| Transom (between beams) | TRANSOM |
| Transom (cantilever) | INFLUENCE |
| Girders | BEAM |
| Stringers | BEAM |
| Deck | DECKSLAB |



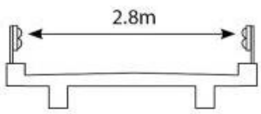
Type: Bridge with weak Deck Cantilevers

| Component | Element |
|---|---|
| Beams | BEAM |
| Deck (interior) | DECKSLAB |
| Deck (cantilever) | CHECK 3 eg 'Vehicle to be positioned at least 1.0m from barrier.' (to ensure no deck cantilever loading) |



Type: Widened Bridge with one lane (HCUs) much stronger than other lane

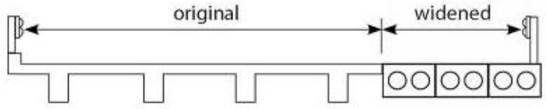
| Component | Element |
|---|---|
| Beams (original and widened) | VBEAM<br>CHECK 2 eg 'Travel in northbound lane vehicle positioned 1m from barrier.' |
| Deck | DECKSLAB |




Type: Very Narrow Deck

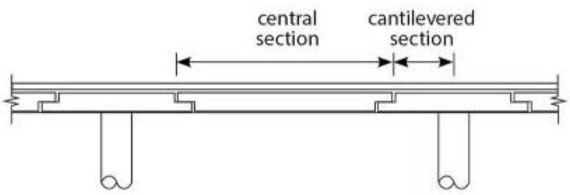
| Component | Element |
|---|---|
| Beams | BEAM |
| Deck | DECKSLAB |
| Deck | CHECK 1 eg 'Available deck width 2.8m; confirm axle width ≤ 2.7m.' |

Figure 3.3: Element types for typical bridges (continued)



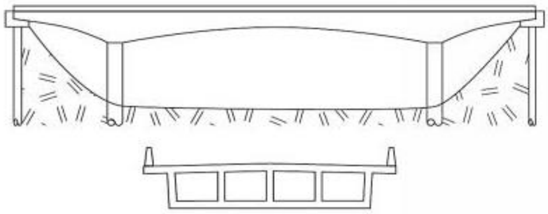

Type: Widened Bridge

| Component | Element |
|---|---|
| Beams (original and widened) | VBEAM |
| Deck (original) | DECKSLAB |




Type: Hinged-In-Span Bridge

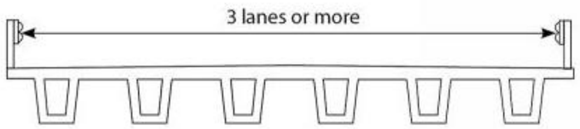
| Component | Element |
|---|---|
| Central section beams | BEAM |
| Cantilevered section beams | INFLUENCE |
| Deck | DECKSLAB |



Type: Continuous Superstructure

| Component | Element |
|---|---|
| Deck | DECKSLAB |
| Beams | BEAM* |

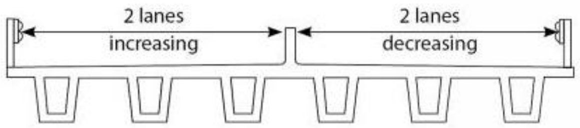
- *BEAM element modified for continuous structural form




Type: Wide Bridge

| Component | Element |
|---|---|
| Deck | DECKSLAB |
| Beams | BEAM* |

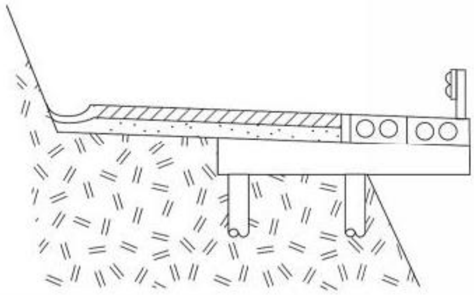
- *Model as '2 lane bridge' with capacity based on '2 lane width'




Type: Wide Bridge with Median Barrier

| Component | Element |
|---|---|
| Deck | DECKSLAB |
| Beams | BEAM* |

- *Separate BEAM element for each direction



Type: Cantilever Half Bridge

| Component | Element |
|---|---|
| Hollow core beams | VBEAM |
| Pier cantilever | INFLUENCE |
| Embankment | CHECK 2 eg 'Position vehicle as close as possible to uphill bank'. |

Figure 3.3: Element types for typical bridges (continued)

# 4 OPERMIT ANALYSIS

## 4.1 General

OPermit selects all bridges between the beginning and the end of a proposed route segment and processes these in the order and direction that the overweight vehicle would cross them.

The elements for each bridge on the route are processed, with the resulting restriction levels aggregated and final restriction levels determined for each bridge for each direction of travel by the overweight vehicle.

## 4.2 Terms and conditions

The permit process and logic introduces a number of technical terms that are defined either in this data guide or by appropriate reference to other documentation.

In relation to bridge element data, ‘longitudinal’ generally means parallel with the direction in which a vehicle travels, and ‘transverse’ generally means perpendicular to the direction of vehicle travel.

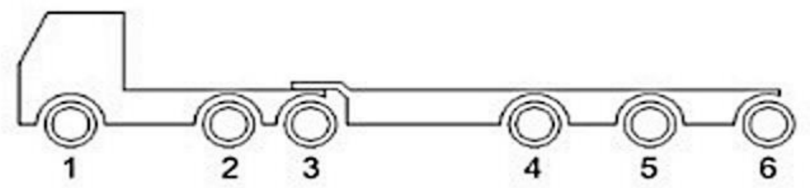
Terms such as eccentricity factor, overload moment capacity and overload shear capacity are defined in section 5. The HN and HO design loadings are defined in the *Bridge manual* (SP/M/022).

| Term | Definition |
|---|---|
| Reference axle mass | A nominal mass given to an axle that takes into account the axle type and spacing. These masses are defined in sections B9.5 to B9.8 of the *Vehicle dimension and mass permitting manual*, volume 1. In general terms, the reference axle mass is equivalent to the legal axle mass. |
| AI | Axle index. The AI for an axle is the axle mass divided by the reference axle mass for that axle. $$\text{Axle index, AI} = \frac{\text{axle mass}}{\text{reference axle mass}}$$ |
| VAI | Vehicle axle index. The VAI is the maximum AI for the vehicle. Refer to chapter B9 of the *Vehicle dimension and mass permitting manual*, volume 1 for examples.<br>The VAI is an indicator of the extent to which axles of a particular vehicle are loaded and hence the effect of those axles on bridge decks. |
| Reference gross mass | The reference gross mass for any group of axles is the nominal allowable mass given to that group of axles.<br>In general terms, the reference gross mass is equivalent to the legal mass limits. These masses are defined in section B10.2 of the *Vehicle dimension and mass permitting manual*, volume 1; they have been devised specifically for the purpose of VGI calculations as a means to derive an indicator for the impact of vehicle mass on a structure. |
| GI | Gross index. The GI for a group of axles is the sum of the axle masses for the group divided by the reference gross mass for the group wheelbase. |

| Term | Definition |
|---|---|
| VGI | Vehicle gross index. The VGI is the maximum GI for the vehicle. Refer to section B10.1 of the *Vehicle dimension and mass permitting manual*, volume 1 for examples.<br>The VGI is an indicator for the effect of the gross mass(es) of a vehicle on a bridge. |
| Critical wheelbase | The axle group first to last axle distance for the particular axle group configuration that produces the VGI. |
| Posting | A Posting value applies if the capacity of the bridge is such that it is not able to accommodate the legal traffic load as defined in the *Bridge manual*. The Posting value is shown as a percentage of the legal load rounded to the nearest 10%. |

## 4.3 Overweight vehicle definition

The OPermit applicant defines the overweight vehicle by: its number of axles, respective axle loads, axle types, tyre sizes, track dimensions and relative spacings, as well as the maximum load width. Refer to section B1.1 of the *Vehicle dimension and mass permitting manual*, volume 1 for specific information.




| Axle number | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Axle type | S | T | T | 8 | 8 | 8 |
| Axle mass (T) | 6.0 | 9.0 | 9.0 | 11.0 | 11.0 | 11.0 |
| Axle spacing | 4.0 | 1.2 | 6.2 | 2.4 | 2.4 | |
| Tyre size | STD | STD | STD | STD | STD | STD |
| Track, outer | 2.0 | 1.9 | 1.9 | 2.0 | 2.0 | 2.0 |
| Track, inner | | | | 0.5 | 0.5 | 0.5 |

Figure 4.1: Key overweight vehicle information

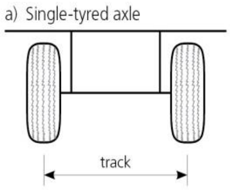
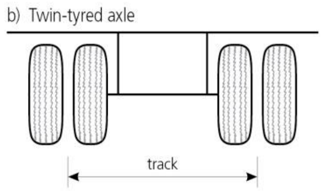
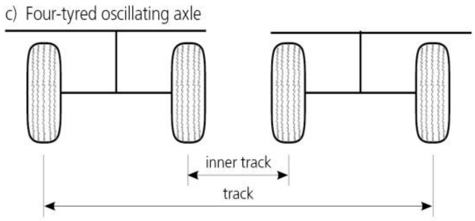
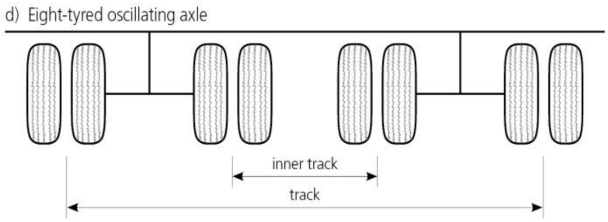
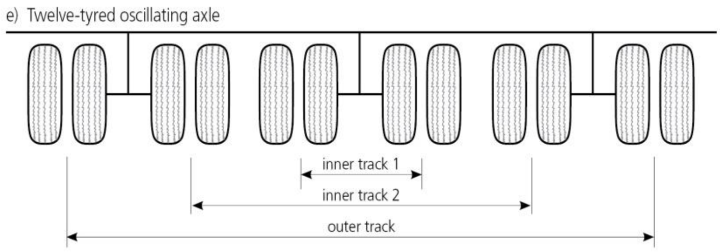
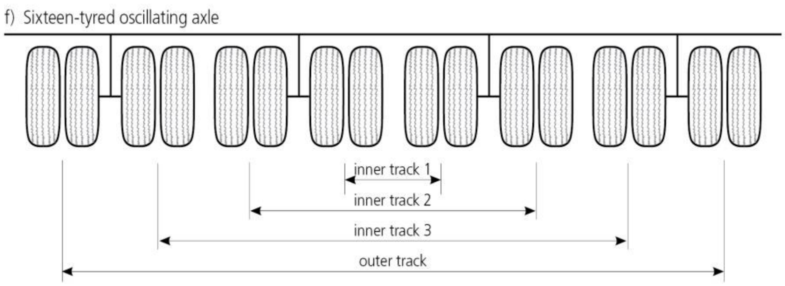
| TYPE | CONFIGURATION |
|---|---|
| S |   |
| T |   |
| 4 |   |
| 8 |   |
| 12 |   |
| 16 |   |

Figure 4.2: Axle configurations

## 4.4 Load lanes

### 4.4.1 Single lane bridges

Bridges with a carriageway width of < 6.0m are treated as single lane bridges. For these bridges, the live load assessment is based on a single lane of loading.

OPermit applies the overweight vehicle load to the bridge with no other loading considered.

### 4.4.2 Two lane bridges

Bridges with a carriageway width of 6.0m or greater are treated as two lane bridges.

For BEAM, VBEAM and TRANSOM elements (only):

- OPermit applies the overweight vehicle load together with one lane of legal load if the carriageway width is sufficient (see figure 4.3 below). For the additional lane of legal load to be applied:

  Bridge carriageway width must exceed
  $$0.5 \times (\text{overweight rim width} + \text{overweight load width}) + 3.3\text{m}$$

- Otherwise, only the overweight vehicle load is applied to the element.
- The legal load applied by OPermit to the adjacent lane is currently set at 0.85HN but is intended to be increased to allow for high-productivity motor vehicles (HPMVs).

For DECKSLAB, TIMBDECK, and INFLUENCE elements:

- Only the overweight vehicle load is applied to the element calculations. The reasoning behind this is provided in the relevant part of section 5.

### 4.4.3 Bridges with three or more lanes

For bridges with three or more lanes, OPermit applies the overweight vehicle load together with a maximum of one lane of legal load (depending on the element type, as above). In some cases this may be unconservative and adjustments to the bridge element data may be needed to ensure appropriate outcomes. Refer to section 5.4.

## 4.5 Overweight vehicle transverse positioning

For BEAM and INFLUENCE elements, only two transverse positions are recognised for an overweight vehicle on a bridge carriageway. These are informally referred to as ‘overweight vehicle in own lane’ and ‘overweight vehicle central’.

For TRANSOM elements, two transverse overweight vehicle positions are considered for ‘overweight vehicle in own lane’ – one position each to calculate the critical moment and the shear. A further overweight vehicle position is considered for ‘overweight vehicle central’.

For VBEAM and transversely spanning TIMBDECK elements for which the element position(s) relative to the carriageway have been described, a number of transverse vehicle positions are considered for ‘overweight vehicle in own lane’ between the following limits:

If there is insufficient room on the carriageway for legal vehicles as well as the overweight vehicle's load width with a 0.3m gap in between, then the overweight vehicle is checked for all physical positions between kerbs or barriers. See figure 4.3.

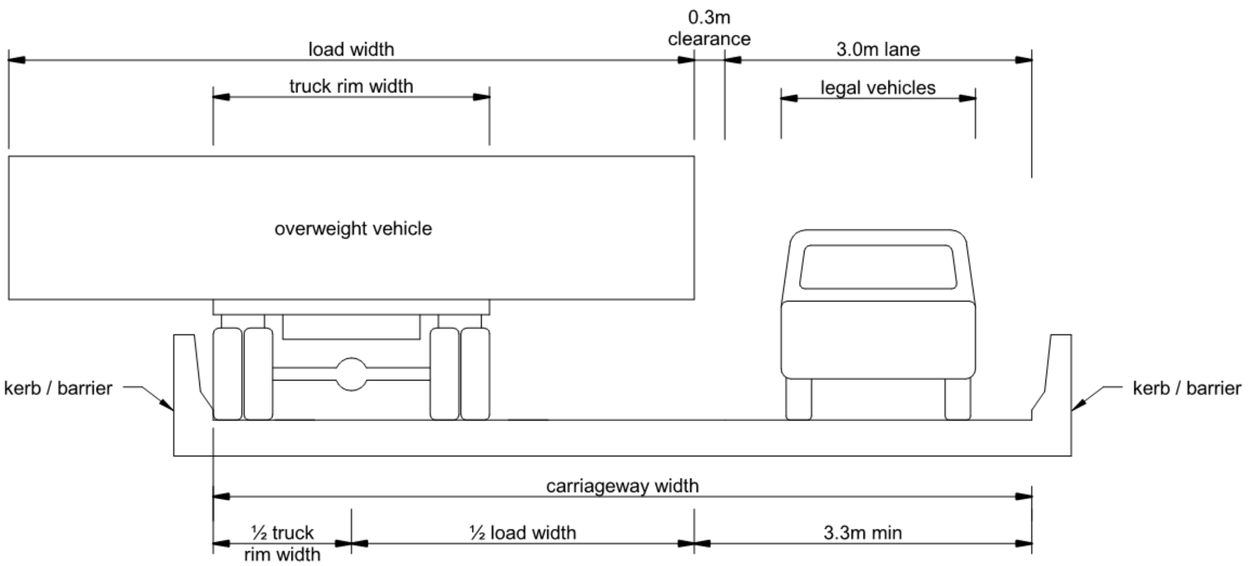



Figure 4.3: Load positions

Otherwise, the number of lanes loaded equals 2 and all transverse overweight vehicle positions are considered between the limits of the kerb and the bridge centreline or between the limits of the kerb and a position with the overweight vehicle 0.2m out from the kerb, whichever gives the greater amount of transverse travel.

For VBEAM elements, and for transversely spanning TIMBDECK elements for which element position data have been stored, the transverse overweight vehicle position for 'overweight vehicle central' is dictated by the RestrictX value (see section 4.6), and the overweight vehicle centreline is placed as close as physically possible to this position.

For transversely spanning TIMBDECK elements for which position data have not been stored, and for longitudinally spanning TIMBDECK elements, it is assumed that the overweight vehicle can be placed anywhere on the element that will produce the worst possible effects.

If a uni-directional bridge has insufficient capacity, the program will also check a parallel bridge in the opposite direction if the bypass code indicates that it is a possible alternative.

## 4.6 Restriction levels

Restriction levels refers to the successively greater restrictions applied to an overweight vehicle until its effects are acceptable.

Each element is first checked at restriction level –1 (no speed limit with the overweight vehicle in its own lane and with an adjacent lane carrying a legal load if applicable). If this unrestricted passage of the overweight vehicle creates a structural effect on any element that is greater than its actual capacity, successively greater restrictions are applied until the effects of the overweight vehicle are acceptable.

The inherent assumption with this assessment is that the dynamic load factor reduces with reduced speed. The relationship between speed and dynamic load factor coded in the OPermit system is outlined in section 4.8.

If restriction level 3 is insufficient to allow access across any bridge, that bridge must not be crossed. Restriction levels –1 to 4 are applied in the order shown below:

| Restriction level | Restriction |
|---|---|
| -1 | Unrestricted travel in own lane |
| 0 | Speed restricted to 50km/h in own lane |
| 1 | Speed restricted to 20km/h in own lane |
| 2 | Speed restricted to a crawl in own lane |
| 3 | Crawl speed, no other traffic on the bridge and overweight vehicle central (or at position RestrictX) on bridge |
| 4 | Overweight vehicle must not cross |

Note that restriction level 3 involves a specific transverse position of the overweight vehicle in order to minimise the load effects on the bridge. Usually this means that the overweight vehicle is kept over the centre of the beam system. For brevity, this guide often refers to this restriction level as ‘overweight vehicle central’. For bridges that have a non-symmetrical transverse section, the optimum position (defined by the RestrictX value) may in fact be some distance from the centre of the carriageway.

Vehicles with off-road tyres are restricted by the normal policy requirements to a maximum speed of 35km/h since they are inclined to bounce and produce a greater dynamic load than normal. If restriction level 1 is found to be necessary for these vehicles, the requirements for restriction level 2 are printed out.

For some bridges (in particular very long bridges), restriction level 3 (crawl central) can be extremely disruptive to traffic flow, as all traffic is effectively prevented from travelling on the bridge while the overweight vehicle travels slowly across it. Analysis often shows that while an overweight vehicle might fail the restriction level 2 (crawl own lane) check, it would satisfy criteria that are less restrictive than restriction level 3, such as ‘20km/h, central’. In such cases, the CHECK element (CHECK 1) should be used to instruct the PIO on the procedure required to confirm this less-restrictive travel condition. Refer to the CHECK 1 example in section 5.8.3.

# 4.7 Vehicle load

## 4.7.1 Overweight vehicle load

The overweight vehicle load comprises the specific axle masses and spacings as nominated in the permit application.

## 4.7.2 Legal load

The legal load is used to represent a lane of normal traffic on a bridge. It represents vehicles conforming to Class 1 that are allowed on the bridge. The legal load used in calculations and shown in output is:

$$0.85 \times \text{HN effect} \times (\text{Posting}/100) \times I_0$$

$I_0$ is the dynamic load factor for normal traffic and is calculated in accordance with figure 3.2 of the *Bridge manual.*

### 4.7.3 Rating loads for OPermit element parameters

For the purpose of determining bridge load distribution parameters (Estd, Ecentre, Bstd, Bcentre), the following loads are used:

- Normal width vehicles – the rating load is based on 85% HO-72, with any adjacent lane (for bridges with a carriageway width ≥ 6.0m) loaded to a proportion of HN-72 in accordance with section 7.4.4 of the *Bridge manual*.
- Platform trailers (12 and 16 type axles) – 85% of HO-72 but with the loaded width increased to 5.25m for 12 type axles and to 7.0m for 16 type axles.

## 4.8 Dynamic load factor (DLF)

The effect of applying increasing restrictions is to reduce the dynamic load factor. The dynamic load factor $I_v$ for any restriction level is calculated in accordance with the stored Impact Code as follows:

| Impact code | | Equation |
|---|---|---|
| 1 | | $I_v = 1.0$ |
| 2 | | $I_v = (1.0 + 0.1 \times Kv) \times Ks$ |
| 3 | For shear: | $I_v = (1.0 + 0.1 \times Kv) \times Ks$ |
| | For moment: | $I_v =$ the lower of $(1.0 + 0.1 \times Kv) \times Ks$ and $[1.0 + Kv \times 5/(L + 38)] \times Ks$ |
| 4 | | $I_v = (1.0 + 0.15 \times Kv) \times Ks$ |
| 5 | For shear: | $I_v = (1.0 + 0.15 \times Kv) \times Ks$ |
| | For moment: | $I_v =$ the lower of $(1.0 + 0.15 \times Kv) \times Ks$ and $[1.0 + Kv \times 7.5/(L + 38)] \times Ks$ |

In the above:

- $I_v$ = dynamic load factor
- L = the span of the element in metres
- Kv is a function of overweight vehicle speed
- Ks is a function of overweight vehicle speed.

Applications are generally as follows:

| Impact code | Application |
|---|---|
| 1 | Timber |
| 2 | Concrete deck slabs |
| 3 | Main members other than timber (normal circumstances) |
| 4, 5 | Members subjected to abnormally severe impact (eg beams adjacent to a poorly aligned bridge approach or beams supporting a sagging or uneven deck) |

Values of Kv and Ks used in the impact equations are:

| Restriction level | Kv | Ks |
|---|---|---|
| -1 | 3 | 1.1 |
| 0 | 3 | 1.0 |
| 1 | 2 | 1.0 |
| 2 | 0 | 1.0 |
| 3 | 0 | 1.0 |

The Ks factor at restriction level –1 is set at 1.1 to represent the increased impact loading that can result from certain tyre types specific to overweight vehicles.

## 4.9 Detailed element checks

A description of each detailed element check procedure is given in section 5.

## 4.10 Member capacity evaluation

The evaluation of member capacities associated with each of the elements is included in section 5 for each element type.

The recommended assumptions relating to material properties and capacity assessment are outlined in section 7 of the *Bridge manual*.

Note that the documented member capacities are the overweight live load capacities.

## 4.11 CHECK elements

It is not always necessary to use structural elements alone to allow the suitability of a bridge to be evaluated. CHECK elements may be used to explain specific requirements or alert users to specific issues.

Separate CHECK elements provide additional information to the PIO, the Assessing Engineer (AE) and the driver.

For example, CHECK elements can be used to limit the position of the vehicle (message to the driver), to alert to the need for a specific check (message to the PIO) or to request a specific structural confirmation (message to the AE).

Refer to section 5.8 for further information.

# 5 BRIDGE DATA EVALUATION

## 5.1 GENERAL element data

### 5.1.1 GENERAL element overview

The GENERAL element is used to record data specific to each structure. It comprises four parts: location data, bypass data, posting data and structural data. A GENERAL ELEMENT DATA form (Form No. BSD1) must be completed for every structure.

The bridge is represented by the GENERAL element and in more detail by a number of other standard elements (DECK, INFLUENCE, TIMBDECK, BEAM, VBEAM, etc). Each of these standard elements corresponds to a component or a number of similar components on the bridge. Data from the GENERAL element are used by many of these other elements.

### 5.1.2 GENERAL element data (Form no. BSD1)

The following tables give details of the input requirements for the GENERAL element data form.

Table 5.1.1: GENERAL element – location data

| Form no. BSD1 input data | Specification | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Bridge Name | The name signposted on the bridge (usually the river or stream name) or, if not signposted, the name by which the bridge is known.<br>If a bridge is also known by an alternative name (eg if the bridge and the waterway have different names), this is shown additionally in brackets, eg INANGAHUA RIVER (REEFTON) BRIDGE.<br>The maximum number of characters is 255. | M |
| Road Identification | For state highways, the relevant state highway number.<br>The maximum number of characters is 25. | M |
| Route Position | The route position (RP) where the bridge is located, taken at the first abutment in the increasing direction. For state highways, the RP is the Reference Station (RS) distance plus the displacement from the RS (in km).<br>The format is RS/displacement, eg 30/6.38. | M |
| Bridge Structure Number (BSN) | The bridge structure number (BSN) is the (signposted) number assigned to the structure. The number must be unique to the road. For state highways, it is an integer calculated by adding the displacement to the Route Position, multiplying by 10 and rounding to the nearest integer.<br>The maximum number of characters is 8. Null value is not accepted. | M |
| Road Controlling Authority or NZTA Region | The name of the road controlling authority or, for NZTA bridges, the NZTA region in which the structure is situated, as follows:<br>Northland<br>Bay of Plenty<br>Taranaki<br>Nelson/Marlborough<br>Otago<br>Auckland<br>Gisborne<br>Wanganui/Manawatu<br>Canterbury<br>Southland<br>Waikato<br>Hawkes Bay<br>Wellington<br>West Coast | M |

Table 5.1.2: GENERAL element – bypass data

| Form no. BSD1 input data | Specification | Mandatory (M) / Default (D) Optional (O) |
|---|---|---|
| Bypass Type | Indicates whether a bypass is available for the bridge and, if so, the type of bypass:<br>0 No bypass exists<br>1 An off-highway bypass exists<br>2 A bypass exists consisting of a bridge for traffic in the opposite direction<br>3 Two forms of bypass exist – one being an off-highway bypass and the other being a bridge in the opposite highway direction | M |
| Bypass Description | The description of any off-highway bypass eg 'adjacent highway ford available'.<br>The maximum number of characters is 255. | O |

Table 5.1.3: GENERAL element – posting data

| Form no. BSD1 input data | Specification | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Posting | The posted gross mass limit on the bridge as a percentage of the Class 1 posting load. If the bridge is not posted, the input is zero (0) and the value of Posting is taken as 100 and printed out as NONE.<br>If the bridge is posted with other than a percentage of Class 1, a CHECK element may be used to inform the PIO, AE or driver of any extra bridge-specific requirements. | M |

Table 5.1.4: GENERAL element – structural data

| Form no. BSD1 input data | Specification | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Direction | Defined as the normal traffic direction catered for by the bridge. Direction codes are:<br>1 For two-way traffic (one, two or more lanes)<br>2 For one-way traffic in the direction of increasing route position<br>3 For one-way traffic in the direction of decreasing route position | M |
| Width | The carriageway width as measured between kerb or guardrail faces, measured to two decimal places. | M |
| RestrictX | RestrictX defines the optimum vehicle centreline transverse position at restriction level 3 to maximise loading capacity.<br>RestrictX Increasing: The optimum transverse position (in metres) from the left-hand carriageway edge in the increasing direction (see figure 5.1.1) for the overweight vehicle centreline for restriction level 3. A zero (0) value indicates that the optimum position is central on the carriageway.<br>RestrictX Decreasing: The optimum transverse position (in metres) from the left-hand carriageway edge in the decreasing direction (see figure 5.1.1) for the overweight vehicle centreline for restriction level 3. A zero (0) value indicates that the optimum position is central on the carriageway.<br>Where RestrictX values are other than central on the carriageway, a CHECK 2 message must be provided to describe how the vehicle is to be positioned on the carriageway.<br>[Note: In earlier versions of OPermit, only a single RestrictX data field was required. Consequently, some bridges may have a value in the RestrictX Increasing field but no data in the RestrictX Decreasing field. This does not affect the processing of overweight permits.] | M |
| Comments | Comments are messages to explain specific issues associated with the structure. Each element also has provision for comments.<br>Note that where a message is specifically required as part of the permit process to advise the PIO, AE or vehicle driver, then the CHECK element should be used because this is presented during the permit process. Comments messages should otherwise be used to inform OPermit users of any specific structure assumptions or issues which could affect the future management of data or any other matters. Note that the Comments messages are only displayed with data output and are not shown during permit processing.<br>Typical examples of Comments messages are:<br>'Material testing & grillage analysis was carried out by bridge consultant in 1999'<br>'The culvert is a Class 2 pipe on Type B bedding, with an assumed 0.9m of fill. The culvert was analysed based on a 3.67m wide strip'<br>'Details of deck slab span 2 not known'<br>'MCAP and SCAP specified for equivalent 3.5m width'.<br>The maximum number of characters is 255. | O |

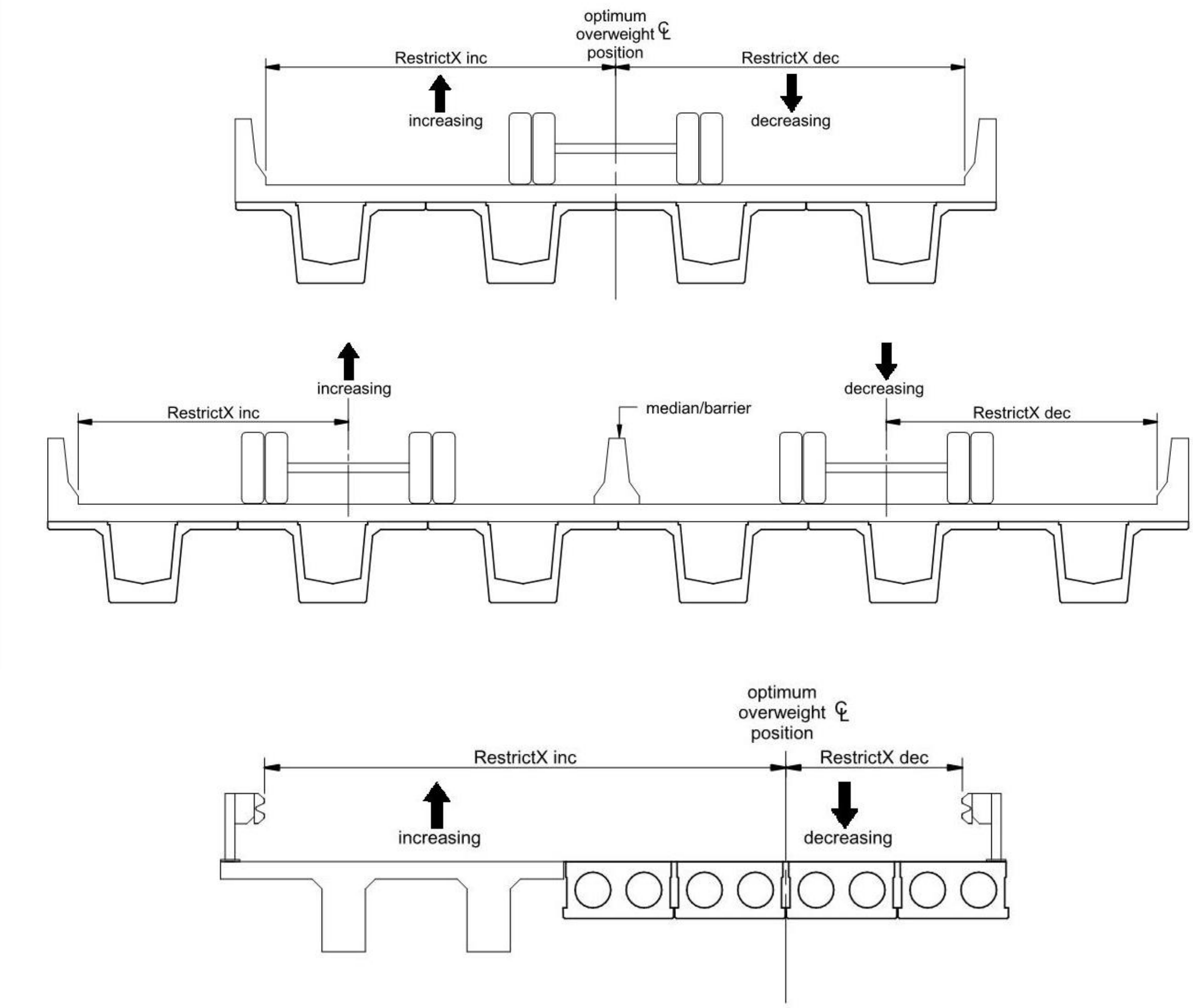



Figure 5.1.1: Typical bridge cross-sections showing RestrictX conventions

## 5.2 DECKSLAB element data

### 5.2.1 DECKSLAB element overview

This element is used to review the capacity of reinforced concrete deck slabs. A simple check is carried out by OPermit. The check is based on the deck capacity factor (DCF) input under the DECKSLAB element.

1. The deck loading ratio (DLR) = VAI/DCF is calculated. If the DLR is ≤ 1.3, the overweight vehicle is allowed to travel over the DECKSLAB element unrestricted, ie restriction level –1.
2. If the DLR does not satisfy this requirement, the vehicle passes to the next restriction level and the VAI is reduced by the ratio of the dynamic load factors at the current and the previous unacceptable restriction level. The DLR is again calculated to assess whether this is ≤ 1.3.

This process is iterated until it is satisfied. That restriction level is then output for the DECKSLAB element for comparison with other bridge elements.

The procedure for calculating the DCF is included in section 7.5 of the *Bridge manual*.

Some types of bridge have a structural form that is not critical for wheel loads. Examples are double hollowcore units, buried slabs, or flat-slab type bridges with thick roof slabs. For some of these structures, a default value of 9.99 was used historically in the BDS data to indicate that the deck was non-critical. For these cases, there is no requirement to provide a DECKSLAB element.

The Transport Agency has a development project underway which is investigating additional methods that could be implemented within OPermit to reduce the conservatism of the current DECKSLAB element, particularly for weaker deck slabs. This will focus on a procedure that uses different DCFs for specific overweight vehicle axle types and loadings, rather than simply considering the most adverse DCF for all axle types.

[Historically, the DECKSLAB element stored a large amount of other deck data for analysis using a grillage analysis model. That model is no longer used. It is proposed that an 'Enhanced DCF' model be developed to allow analysis of different axle types.]

### 5.2.2 Recommendations for specific cases

Weak deck cantilevers supporting shoulders

It is relatively common for some bridges to have weak deck cantilevers supporting the road shoulder, but internal slabs of higher capacity. This is particularly relevant for deck slabs analysed using empirical designs based on assumed membrane action. If the roadway width allows, consideration could be given to using a CHECK 3 message to advise overweight vehicles to stay off the deck cantilevers. The DCF input for the element would be the value for the internal slabs.

An example of a CHECK 3 message is: 'Vehicle must be positioned greater than 1.3m from guardrail'.

The CHECK 3 message will be presented on the permit as an instruction to the driver for this bridge.

For decks other than of concrete

For timber decks – use the TIMBDECK element.

For deck materials such as steel plate, the DECKSLAB element may be used. If a different DLF (Impact Code) is required, the DCF shall be factored accordingly.

### 5.2.3 DECKSLAB element data (Form no. BSD2)

Table 5.2.1 outlines the input requirements for the DECKSLAB element.

Table 5.2.1: Input data for the DECKSLAB element

| Form no. BSD2 input data | Specification | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Bridge Name | See table 5.1.1 | M |
| BSN | See table 5.1.1 | M |
| Direction | See table 5.1.4 | M |
| Type | DECKSLAB | D |
| Description | A brief description of the deck, eg Span 1 concrete deck.<br>The maximum number of characters is 255. | M |
| Impact Code | The Impact Code is used to identify the appropriate dynamic load factors to be applied to the element at each restriction level. The code is always 2 for DECKSLAB elements:<br>Impact Code = 2; Application – Concrete deck slabs<br>This value is hard-coded into OPermit. | M |
| DCF | Deck capacity factor – see section 7.5 of the *Bridge manual*. | M |
| Comments | Comments may be provided to elaborate on any assumptions or relevant issues or information affecting the development of data which may be important for future reference.<br>The maximum number of characters is 4000. | O |

### 5.2.4 DECKSLAB examples

DECKSLAB examples will be posted on the Transport Agency website as they become available. Please check the webpage of this guide, which may be accessed via www.nzta.govt.nz/resources.

# 5.3 TIMBDECK element data

## 5.3.1 Simple check using TIMBDECK DCF

A DCF (deck capacity factor) is input for the TIMBDECK element. OPermit uses this as a simple check. The procedure for calculating the DCF is outlined in section 7.5 of the *Bridge manual*.

The deck loading ratio (DLR) = VAI/DCF is calculated by OPermit.

- If the DLR is < 1.30, then the overweight vehicle is unrestricted, ie restriction level –1. The detailed TIMBDECK calculations will not be undertaken.
- If the DLR is > 1.30, then the detailed TIMBDECK calculations will be undertaken as outlined below.

## 5.3.2 TIMBDECK element overview

TIMBDECK is used to model timber decks spanning longitudinally or transversely. Timber decks may comprise simply supported planks, or planks continuously spanning a number of beams. Figures 5.3.1 and 5.3.2 detail the arrangements for transversely and longitudinally spanning timber decks.

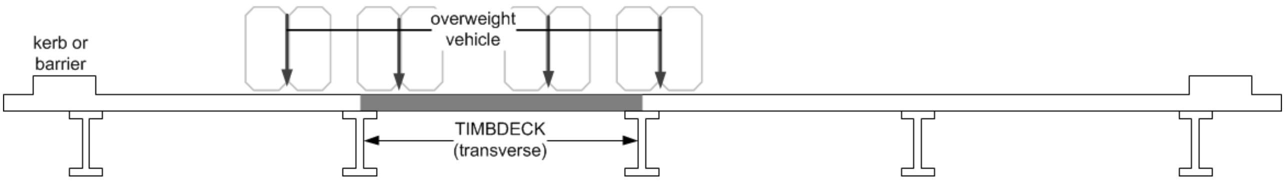



Figure 5.3.1: Typical bridge cross-section showing transverse timber deck arrangement

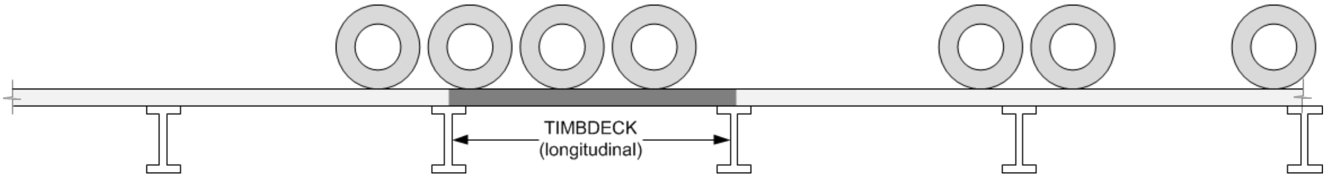



Figure 5.3.2: Typical bridge elevation showing longitudinal timber deck arrangement

The effect of any legal load in an adjacent lane is not considered, although its presence can constrain the position of the overweight vehicle. For transversely spanning elements, this simplification is made because of the relatively short spans involved. For longitudinally spanning elements, it is made because of the relatively narrow distribution width.

TIMBDECK elements (see section 5.3.3. for element descriptions) are analysed as simply supported beams. If the decking is continuous over two or more spans, the moment capacity per unit width may be increased by 25% before being stored.

The capacities used for comparison with the calculated moment and shear are taken as the capacity per unit width multiplied by the distribution width. The distribution widths are detailed in table 5.3.1.

Table 5.3.1: Distribution widths used by the TIMBDECK element

| Dist Code (see table 5.3.2) | Distribution width |
|---|---|
| 1 | Tyre contact dimension perpendicular to deck span and rounded up to next whole plank |
| 2 | Tyre contact dimension perpendicular to deck span and rounded up to next whole plank + 1 plank |
| 3 | Tyre contact dimension (perpendicular to deck span) + 0.4 × (Plank) × (Span) |
| 4 | Tyre contact dimension (perpendicular to deck span) + 0.8 × (Plank) × (Span) |
| 5 | Tyre contact dimension (perpendicular to deck span) + 1.5 × (Plank) × (Span) |
| 6 | Tyre contact dimension (perpendicular to deck span) + 3.0 × (Plank) × (Span) |

Note: Currently only Dist Codes 1 to 4 are available. See table 5.3.2 for descriptions of input data.

Tyre loads are considered to be uniform loads, and are applied over the contact dimension in the direction of the deck span.

### Transversely spanning elements

For transversely spanning TIMBDECK elements (Type Code = 1), each vehicle axle is applied to the element in turn. It is assumed that only one axle is present on the critical part of the element at any time. Use is made of element and vehicle symmetry.

- If no Position values have been stored, the axle is incremented across the element, starting with the right-hand wheel at mid-span and finishing when the centre of the axle is at mid-span.
  - The worst moment effect is assumed to lie within these limits.
  - The worst shear effect is found by placing the axle so that the left-hand outer wheel is just fully on the left-hand edge of the element.
  - If the axle has 4 or 8 wheels, a second vehicle position is investigated for shear effects. This second position places the left-hand inner wheel just fully on the left-hand edge of the element.
- If Position values are supplied, the location of the left-hand side of the element is defined relative to the left-hand kerb, and therefore relative to the carriageway. The vehicle is incremented across the available region of the carriageway, taking into account adjacent lane loading and the location of the timber deck element.
  - When incrementing the vehicle, the rim width (distance between the outside face of the outer tyres) is used as it is assumed that the vehicle is able to overhang barriers.
  - For each axle, moment effects are calculated for each increment position and the maximum is used.
  - For each axle, the worst shear effect is found by placing each wheel in turn as close as physically possible to a position where the wheel is just fully on the element.

The use of Position data is only recommended for single lane bridges where a critical element is likely to be avoided due to bridge geometry.

For transversely spanning timber deck cantilevers that are able to be loaded by vehicles (eg planks spanning beyond an outer steel beam), the deck can be modelled using the INFLUENCE element. See example 5 in section 5.7.3.

### Longitudinally spanning elements

For longitudinally spanning elements (Type Code = 2), each axle of the vehicle is applied to the span in turn. Each axle is placed so that the contact length is just on the span. The axle is then incremented along the span until it is just off. The maximum moment and shear are determined from each incremental position, taking into account any other axles able to be concurrently on the span.

In some cases, distribution widths for each tyre may overlap. This is only likely to occur with Dist Codes 4, 5 and 6. Where distribution widths overlap, the loading effect is doubled because two tyres are acting on the same portion of timber deck. If this double-loaded patch was used in the assessment process, it would produce an unrealistic and overly conservative outcome. OPermit therefore redistributes the peak load over a characteristic width. The characteristic width is the distribution width of the narrowest tyre taken from any axle of the vehicle. For example, if the first axle of the overweight vehicle has narrow single tyres, this would usually be used to calculate the characteristic width. Figure 5.3.3 details how the averaging process is used to calculate the load intensity used by OPermit.

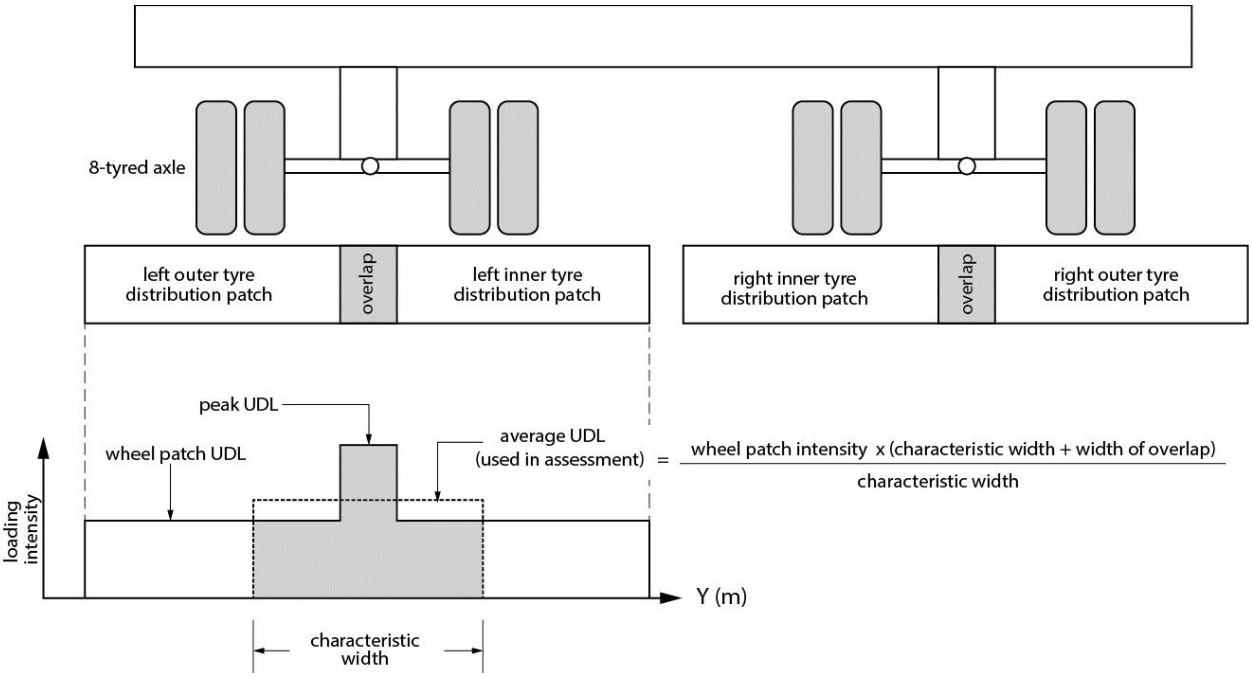



Figure 5.3.3: Calculating the axle loading intensity for longitudinal members

### Cantilevered elements

The TIMBDECK element does not cater for cantilevered timber decks. Such deck elements can be managed in three ways:

1. DCF method. Calculate the appropriate DCF for the deck cantilever. If it is the critical DCF, this will be the value specified.
2. CHECK element method. If the vehicle is able to be positioned to avoid the cantilever, specify this as a CHECK 3 element. Refer to example 3 of section 5.8.3.
3. INFLUENCE element method. Refer to example 5 of section 5.7.3.

#### Multiple TIMBDECK elements

Multiple TIMBDECK elements may be entered into OPermit where a bridge has two or more sections of timber deck with differing dimensions or structural arrangements.

Multiple elements should only be input when the OPermit analysis is expected to result in significant differences in the elements' fraction of capacity, when considering various wheel and axle types. Otherwise, only the most restrictive element needs to be specified.

### 5.3.3 TIMBDECK element data (Form no. BSD3)

A number of different TIMBDECK elements may be input for a single bridge, with separate data for each. Table 5.3.2 describes the data requirements for the TIMBDECK element. Mandatory fields must be completed and Default fields are provided by OPermit.

Table 5.3.2: Input data for the TIMBDECK element

| Form no. BSD3 input data | Specification | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Bridge Name | See table 5.1.1 | M |
| BSN | See table 5.1.1 | M |
| Direction | See table 5.1.4 | M |
| Type | TIMBDECK | D |
| Description | A brief description of the TIMBDECK element, eg 'Timber deck span 1'.<br>The maximum number of characters is 255. | M |
| Impact Code | The Impact Code is used to identify the appropriate dynamic load factors to be applied to the element at each restriction level. Applications are generally as follows (see section 4.7):<br>Impact Code — Application<br>1 — Timber<br>2 — Concrete deck slabs (not used for this element)<br>3 — Main members other than timber (normal circumstances)<br>4, 5 — Members subjected to abnormally severe impact<br>Hence, the Impact Code is always 1 for TIMBDECK elements. | M |
| Type Code | 1 = spanning transversely and 2 = spanning longitudinally. | M |
| DCF | Deck capacity factor for this element. | M |
| Span | The effective span of the TIMBDECK element (in metres) taken as the clear distance between supporting members plus one half-width of a supporting member.<br>This should not exceed the clear distance between supporting members plus the element thickness.<br>*continued on following page* | M |

| Form no. BSD3 input data | Specification | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| MCAP | Overload moment capacity per unit width (kNm/m), calculated as total moment capacity minus dead load moment.<br>TIMBDECK elements are analysed as simply supported elements. If the timber deck elements are continuous over two or more spans, MCAP may be increased by 25% (provided that live load moments are being calculated on a simple span basis). Refer to section 7 of the *Bridge manual*.<br>The capacity used for comparison with calculated live load moments is MCAP multiplied by the distribution width identified by the Dist Code (see below). | M |
| SCAP | Overload shear capacity per unit width (kN/m).<br>If shear is not critical, then enter zero (0).<br>The capacity used for comparison with calculated live load shear is SCAP multiplied by the distribution width identified by the Dist Code (see below). | M |
| Plank | The width of the plank for planked decks (Dist Code = 1 or 2) or the depth of the deck for laminated decks (Dist Code = 3 to 6). Refer to table 5.3.1 for distribution widths for each Dist Code. | M |
| Dist Code | This indicates the amount of distribution of a wheel load. The codes are as follows:<br>1 Planks laid flat *without* running planks at least 50mm thick<br>2 Planks laid flat *with* running planks at least 50mm thick<br>3 Nail-laminated deck fabricated in baulks, with no shear connection between them<br>4 Nail-laminated deck with end laminations well supported and:<br>a fabricated in baulks with shear connection between them by steel dowels or other means, or<br>b fabricated in baulks and having running planks over them, more than 50mm thick, or<br>c fabricated continuously in situ across the span, with no unconnected joints between laminations<br>5 Glue-laminated deck, fabricated in baulks with no shear connection between them<br>6 Glue-laminated deck, otherwise as 4a, b or c.<br>Note: Only Dist Codes 1 to 4 are currently available. | M |
| Number | For elements with Type Code 1 only, the number of positions in which the element occurs across the transverse bridge section.<br>This is used in conjunction with Position (see below) to determine the limits on the transverse positioning of overweight vehicles on this element. If stored as zero (0), it is assumed that the vehicle can be positioned anywhere on the element to produce the worst possible effects and restriction level 3 is not checked.<br>*continued on following page* | M |

| Form no. BSD3 input data | Specification | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Position | For Type Code 1 elements only, the *x*-coordinate value (in metres) at which the left-hand edge is positioned. (Looking in the positive highway direction, this is edge 3 of the element; see figure 5.3.4 below.)<br>The number of values to be provided = Number; eg for Number = 3, Position values could be 1.2, 2.4, 3.6.<br>If Number is zero (0), no Position values are stored.<br>Recommended for use with single lane bridges only. | M |
| Comments | Comments may be provided to elaborate on any assumptions or relevant issues or information affecting the development of data which may be important for future reference.<br>The maximum number of characters is 4000. | O |

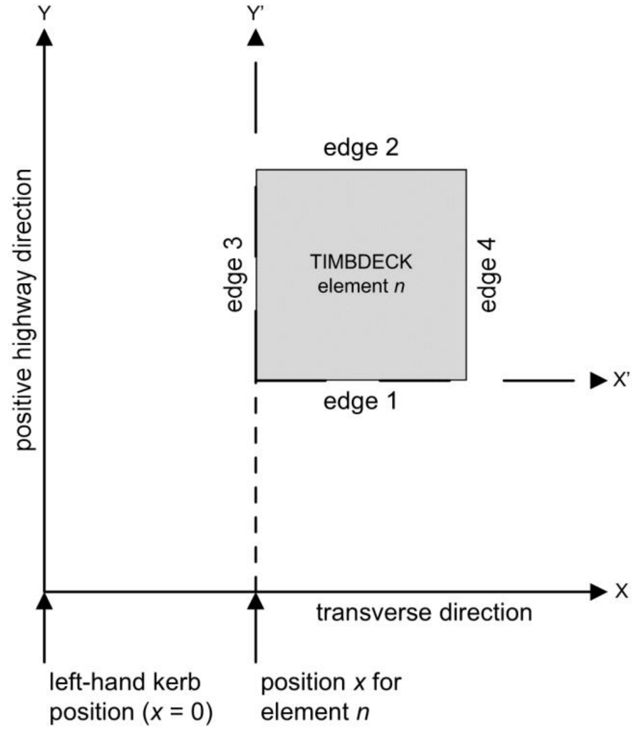



Figure 5.3.4: TIMBDECK element conventions

### 5.3.4 TIMBDECK examples

Example 1: Transverse spanning element

A two lane timber bridge has a carriageway width of 7.5m. The transversely spanning timber deck is constructed from baulks and has running planks over the top (figure 5.3.5). The baulks are 200mm wide by 250mm deep and have a clear span of 2.0m, and are continuous over two spans.

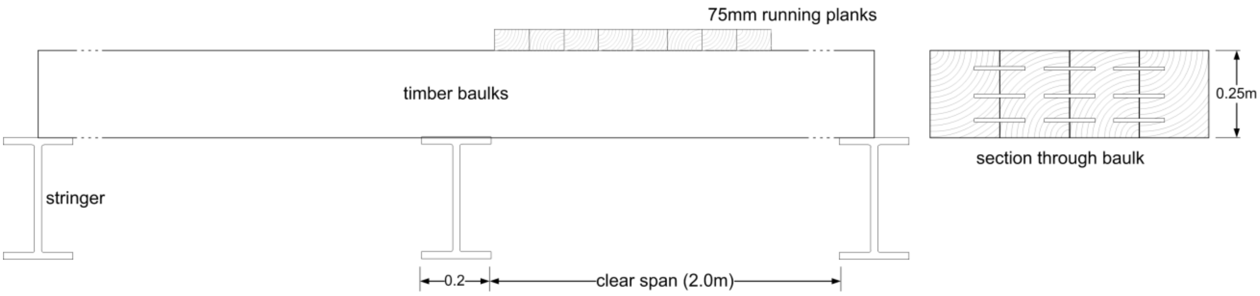



Figure 5.3.5: Baulk deck example

| | |
|---|---|
| Impact Code | As the element is timber, the Impact Code is 1. |
| Type Code | The element is spanning transversely. The Type Code is therefore 1. |
| Span | The clear span of the timber deck is 2.0m, and the stringer width is 0.2m. The Span value is therefore 2.0 + 0.1= 2.1m.<br>This is less than the element thickness plus the clear distance (0.25 + 2.0 = 2.25). |
| MCAP | The MCAP value is calculated in accordance with section 7 of the *Bridge manual*. The calculated value is increased by 25% as the member is continuous over two spans. The 25% increase is applied as the overweight moments are derived by OPermit using a simply supported span. |
| SCAP | The SCAP value is calculated in accordance with section 7 of the *Bridge manual*. |
| Plank | The baulks are part of a laminated deck; the depth of the baulk is therefore used. The Plank dimension is therefore 0.25m. |
| Dist Code | In this case the baulks have running planks. The Dist Code for the bridge is therefore 4. |
| Number | The bridge has two lanes of traffic. As an overweight vehicle can effectively be located at any position on the carriageway, no position data has been provided. Number is therefore zero. |
| Position | No Position data is required as no Number data are given. |

Example 2: Longitudinal spanning element

A single lane timber bridge has a carriageway width of 4.0m. The longitudinal spanning timber deck is constructed from simply supported planks, with a thin chip seal. Each plank spans between transoms (figure 5.3.6). The planks are 0.2m wide by 0.15m deep and have a clear span of 1.0m.

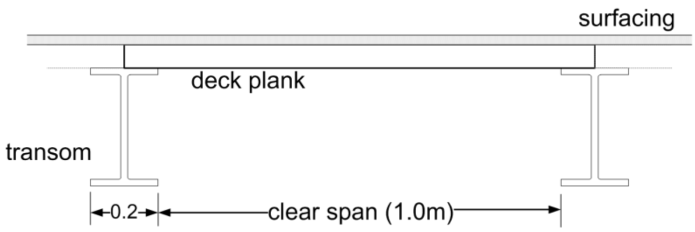



Figure 5.3.6: Timber plank deck example

| | |
|---|---|
| Impact Code | As the element is timber, the Impact Code is 1. |
| Type Code | The element is spanning longitudinally. The Type Code is therefore 2. |
| Span | The clear span of the timber deck is 1.0m, and the supporting beam width is 0.2m. The Span value is therefore 1.1m.<br>The element thickness plus the clear distance is 1.15m, which is more than 1.1. The Span to be input is therefore 1.1m. |
| MCAP | The MCAP value is calculated in accordance with section 7 of the *Bridge manual*. |
| SCAP | The SCAP value is calculated in accordance with section 7 of the *Bridge manual*. |
| Plank | The timber deck is constructed from planks. The width of the planks is therefore used. The Plank dimension is therefore 0.2m. |
| Dist Code | In this case, the timber planks have no extra running planks. The Dist Code for the bridge is therefore 1. |
| Number | Not applicable for longitudinally spanning timber decks. |
| Position | Not applicable for longitudinally spanning timber decks. |

# 5.4 BEAM element data

## 5.4.1 BEAM element overview

The BEAM element is used for longitudinal members, such as main beams, girders, trusses, stringers or long slabs. The BEAM element uses a simplified analysis, adopting an equivalent simply supported element with an eccentricity factor to allow for transverse distribution of vehicle loads. The overweight vehicle is positioned in its own lane or at a pre-defined position transversely on the bridge carriageway, based on the restriction level.

The BEAM element is the preferred element for modelling longitudinal members, as the eccentricity factor may be based on the results of a refined computer analysis procedure such as grillage or the finite element method. Consequently, the BEAM element can incorporate a better assessment of the transverse distribution effects of the vehicle load on the bridge span than is possible with the alternative VBEAM element (described in section 5.5).

The BEAM element generally represents the combined structural capacity of all load-carrying members across the full cross-section of the structure.

OPermit calculates the maximum overweight vehicle moment and shear effects on the BEAM element span. For restriction levels of –1, 0, 1 or 2, an adjacent lane of legal vehicle load (0.85HN × Posting × DLF) is incorporated in combination with the overweight vehicle. For restriction level 3, no other vehicle loads are permitted on the bridge with the overweight vehicle. OPermit does not currently incorporate lane load reduction factors as part of the loading assessment, as this could result in a non-conservative output where an element is more critically loaded by a single vehicle. This also ensures consistency with historical rating assessment data, which generally do not include a lane load reduction factor.

OPermit compares the vehicle moment and shear effect with the stored limiting values of overload moment capacity (MCAP) and overload shear capacity (SCAP). Values for fraction of capacity (FoC) are output, and the reported restriction level is that for which the FoC is the highest but still < 1.0.

Note that spans containing hinges, cantilever spans and some spans with critical sections not at mid-span may be more appropriately modelled using the INFLUENCE element (refer to section 5.7).

## 5.4.2 BEAM element analysis

The BEAM element incrementally moves the overweight vehicle (as defined by the axle masses and spacings) along the BEAM element span, and calculates the maximum moment and shear in the span. A dynamic load factor (DLF – refer to section 4.8) is applied.

For travel in 'own lane' (restriction levels –1, 0, 1 or 2), OPermit incorporates one lane of legal vehicle load alongside the overweight vehicle. The maximum moment and shear for this loading is currently calculated as 0.85HN × Posting × DLF (for normal vehicles). Posting is a stored value for each bridge.

An eccentricity factor is determined, based on the particular load conditions, the Estd and Ecentre data for the element, and element span and width (descriptions of BEAM element input data are given in table 5.4.2). Refer to section 5.4.4 for the detailed methodology. In simple terms:

$$M_{overweight} \times DLF \times \text{eccentricity factor} \leq MCAP$$

The calculation for shear is similar.

For simplicity, the eccentricity factor for shear is assumed to be the same as that for moment. Where this simplification is considered inappropriate, separate BEAM elements for moment and for shear are input with appropriate eccentricity factors.

- For the BEAM element representing moment, choose SCAP = 0 (ie shear is not critical)
- For the BEAM element representing shear, choose an arbitrary MCAP value such that this is not critical.

OPermit will process the elements in series and calculate a restriction level for the bridge based on the most critical result. Where arbitrary MCAP values are adopted, ensure that the Comments field includes the relevant explanation in order to avoid future misinterpretation of data.

### 5.4.3 Eccentricity factors

Eccentricity factors are determined by analysis of the bridge deck with elements of live loading positioned to produce the most adverse load effect for Estd and to produce the least adverse load effect for Ecentre.

The live loading is based on HN-HO-72 loading and the application of the load elements is defined in table 5.4.1.

The eccentricity factors are defined as follows:

- For a beam and slab bridge:

$$e = \frac{\text{moment in most heavily loaded beam (or truss)}}{\text{average moment per beam (or truss)}}$$

- For a slab bridge:

$$e = \frac{\text{peak moment per metre width}}{\text{average moment per metre width}}$$

Eccentricity factors must be $\geq 1.0$.

The eccentricity factor is a measure of the ability of the bridge deck to distribute vehicle loads transversely. A lower factor represents a deck that has a larger degree of transverse stiffness, while a higher value indicates lesser transverse distribution of load and hence higher concentration of load from an overweight vehicle. Where beams or trusses in any span configuration have different capacities, the eccentricity factor must account for the most critically loaded member.

The eccentricity factor should be determined using a method that takes into account the relative stiffness of longitudinal and transverse members and the relative strengths (criticality) of longitudinal members.

- For bridges of one or two lanes, the simplified methods given in AASHTO LRFD *Standard specifications for highway bridges* may be used.
- Where AASHTO is not applicable or where a more refined analysis is likely to improve the load-carrying bridge capacity, a computer grillage analysis should be carried out. The standard reference *Bridge deck behaviour*, 2nd edition, by E.C. Hambly, may be used as a guide for grillage analysis.

Allowing for platform trailers (12 and 16 type axles)

Estd and Ecentre are used for normal-width vehicles up to 8 tyres per axle. For wider vehicles, 12 tyres per axle (5.25m width) and 16 tyres per axle (7m width), Estd and Ecentre can be conservative since the wider vehicles distribute applied loads to a wider section of bridge than the standard 3m load lane.

Estd(12), Estd(16), Ecentre(12) and Ecentre(16) values can be stored for any bridge to cater for these wider vehicles. These values should only be populated where there is relatively frequent use by vehicles with 12 or 16 tyres per axle and where Estd and Ecentre are deemed to be overly conservative. Otherwise, these fields should be populated with zero to indicate that the default is Estd or Ecentre.

Table 5.4.1: Live load cases for eccentricity factors

| No. of lanes on bridge | Estd | Ecentre |
|---|---|---|
| Single lane (width between kerbs of < 6.0m) | For Estd, the rating live load of one lane of 0.85HO, positioned within the marked traffic lanes on the bridge roadway to produce the most adverse effects in the longitudinal elements.<br>For Estd(12), the live load shall be one lane of 0.85HO (with Type 12 axles). This is applicable only to bridges with sufficient roadway width to accommodate the load. | For Ecentre, one lane of 0.85HO, positioned transversely on the bridge roadway within kerbs/barriers to produce the least adverse effects in the longitudinal elements. In other words, the load is positioned to maximise the load capacity of the bridge.<br>This transverse position is defined as RestrictX.<br>For Ecentre(12), the live load shall be one lane of 0.85HO (with Type 12 axles). This is applicable only to bridges with sufficient roadway width to accommodate the load. |
| Two lanes | For Estd, the rating live load of one lane of 0.85HO and one lane of 0.90HN for spans up to 25m, or 0.95HN for spans > 25m.<br>The rating loads shall be applied within the marked traffic lanes on the roadway to produce the most adverse effects in the longitudinal elements.<br>For Estd(12) or Estd(16), the live load shall be one lane of 0.85HO (with Type 12 or 16 axles) and, if the width of the roadway allows for an adjacent lane of legal load, one lane of 0.90HN for spans up to 25m, or 0.95HN for spans > 25m. | The Ecentre live load for two lanes is identical to that for a single lane bridge, ie one lane of the load element, positioned transversely on the bridge roadway to produce the least adverse effects in the longitudinal elements.<br>This transverse position is defined as RestrictX. |
| Three or more lanes | For Estd, the rating live load of one lane of 0.85HO and one lane of 0.90HN for spans up to 25m, or 0.95HN for spans > 25m.<br>The bridge structural data shall be based on an equivalent two lane bridge. Refer to section 5.4.6, Wide bridge decks. Only two lanes shall be loaded. The loaded lanes (overweight load and normal load) shall be chosen to produce the most adverse effects in the longitudinal elements.<br>For Estd(12) or Estd(16), the live load shall be one lane of 0.85HO (with Type 12 or 16 axles) and one lane of 0.90HN for spans up to 25m, or 0.95HN for spans > 25m. | The Ecentre live load for three or more lanes is identical to that for a single lane bridge, ie one lane of the load element, positioned transversely on the actual (three or more lane) bridge roadway to produce the least adverse effects in the longitudinal elements.<br>This transverse position is defined as RestrictX.<br>The bridge structural data shall be based on an equivalent two lane bridge. This approach may be conservative in some cases. Refer to section 5.4.6, Wide bridge decks. |

### 5.4.4 BEAM element algorithms

| Element | Description |
|---|---|
| e | eccentricity factor |
| $I_0$ | dynamic load factor for unrestricted operation |
| $I_v$ | dynamic load factor for the restriction level being considered |
| $M_{overweight}$ | moment on span due to overweight vehicle |
| $M_{HO}$ | moment on span due to HO vehicle |
| $M_{HN}$ | moment on span due to HN vehicle |
| MCAP | overweight vehicle moment capacity of the bridge |
| n | number of beams or width of slab |
| Posting | the posted mass limit for the bridge (%) |
| $S_{overweight}$ | shear on span due to overweight vehicle |
| $S_{HO}$ | shear on span due to HO vehicle |
| $S_{HN}$ | shear on span due to HN vehicle |
| SCAP | overweight vehicle shear capacity of the bridge |
| Width | carriageway width of the bridge |

A. Single lane bridges

This applies for a roadway width of < 6.0m and Estd is assumed to have been calculated for one lane of loading only.

For an overweight vehicle unrestricted in position, the moment in the critical beam (or unit width of slab is:

$$(M_{overweight} \times I_v \times e) / n$$

This must be ≤ MCAP/n for the overweight vehicle to pass.

For a single lane bridge, e = Estd and OPermit checks the following:

$$M_{overweight} \times I_v \times \text{Estd must be} \leq \text{MCAP}$$

For an overweight vehicle at restriction level 3 (crawl central), as defined by RestrictX, OPermit checks the following:

$$M_{overweight} \times \text{Ecentre must be} \leq \text{MCAP (as in this case } I_v = 1.0)$$

Shear is checked in a similar procedure.

If values are provided for Estd(12) or Estd(16), for overweight vehicles with type 12 or type 16 axles, the appropriate Estd value is used in the calculation.

B. Multiple lane bridges

*For restriction levels -1, 0, 1 or 2*

This applies for a roadway width of ≥ 6.0m and Estd is assumed to have been calculated for two lanes of loading.

For a multiple lane bridge with sufficient width for the overweight vehicle and an adjacent lane of legal load, OPermit uses the following relationship for the eccentricity factor:

$$e = \frac{Estd \times (1.3 \times Span/Width + 1/K_{Basic})}{(1.3 \times Span/Width + 1/K)}$$

where:

- $K_{Basic} = M_{HO}/M_{HN}$
- $K = M_{overweight} \times I_v / 0.85 \times M_{HN} \times I_0 \times (Posting/100)$

OPermit calculates the eccentricity factor for a particular overweight vehicle by using an empirical formula that modifies Estd based on the Span/Width ratio of the bridge and the difference between the overweight vehicle moment and the moment caused by HO loading.

K and $K_{Basic}$ are factors that represent the ratio of an overweight vehicle moment to a normal vehicle moment.

The moment in the critical beam (or unit width of slab) is:

$$[M_{overweight} \times I_v + 0.85 \times M_{HN} \times I_0 \times (Posting/100)] \times e/n$$

This must be ≤ MCAP/n for the overweight vehicle to pass.

The OPermit check is therefore:

$$[M_{overweight} \times I_v + 0.85 \times M_{HN} \times I_0 \times (Posting/100)] \times e \le MCAP$$

If a multiple lane bridge is not wide enough to carry the overweight vehicle with an adjacent lane of legal load, then the OPermit checks (ignoring the legal load) are:

$$M_{overweight} \times I_v \times Estd(1 + 1/K_{Basic}) \text{ must be} \le MCAP$$

Shear is checked in a similar procedure.

*For restriction level 3*

For the overweight vehicle at restriction level 3 (crawl central), as defined by RestrictX, OPermit checks the following:

$$M_{overweight} \times Ecentre \text{ must be} \le MCAP \text{ (as in this case } I_v = 1.0)$$

Shear is checked in a similar procedure.

### 5.4.5 Moment and shear capacities

Simple spans

The total overload moment and shear capacity of the bridge (ie total capacity minus permanent loading effects including those due to dead loading and any other concurrent transient effects) is calculated for the total bridge cross-section (or part cross-section if the eccentricity factor has been based on an analysis of part of the bridge cross-section).

The overload moment capacity MCAP is calculated at mid-span. If other cross-sections within the span are critical, the mid-span MCAP value is modified to allow for this. Note that OPermit only checks the mid-span moment for the overweight vehicle on the span. Also refer to section 5.4.6, Beams with critical sections not at mid-span or supports.

The overload shear capacity SCAP is calculated for the cross-section at the end of the span. If other cross-sections within the span are critical, the SCAP value is modified to allow for this. If shear is not critical for the span, the value of zero may be stored and shear will not be checked for the overweight vehicle.

The calculation of the overload capacity $R_o$ for members is defined in section 7 of the *Bridge manual*.

The total bridge overload capacities MCAP and SCAP are equal to the sum of the member overload capacities.

Note that the eccentricity factor definition presented in 5.4.3 and the algorithms presented in 5.4.4 are based on the case where member overload capacities are equal, giving the capacities of the critical beam as MCAP/n and SCAP/n. For the case where member capacities are not equal, eccentricity factors will require modification for use with MCAP and SCAP defined as above. Refer to section 5.4.6 for more information.

Continuous spans or framed spans

For continuous or framed spans, the overload moment capacities at the supports and at mid-span may be combined to provide a single capacity equivalent to a simple span.

The overall overload moment capacity of the span may be converted to that of an equivalent simple span by subtracting (algebraically) the mid-span positive overload moment capacity from the mean of the two negative overload moment capacities at the supports. See figure 5.4.1.

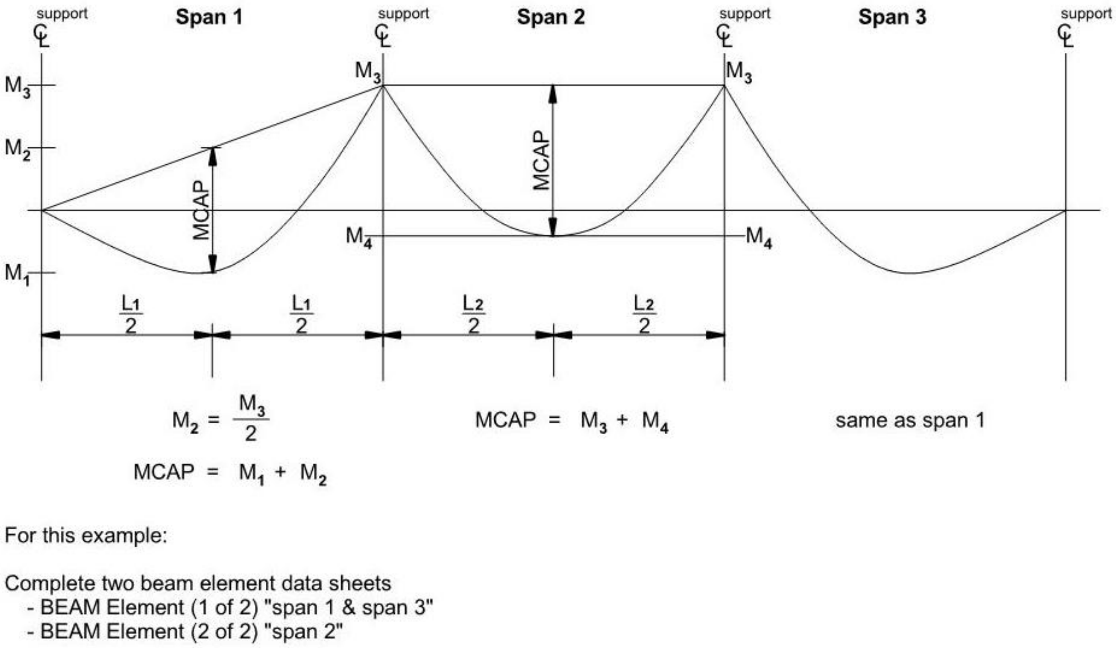



Figure 5.4.1: Modelling continuous bridge spans

The shear capacity SCAP is calculated for the cross-section at the end of the span. As above, if shear is not critical for the span, the value of zero may be stored and shear will not be checked for the overweight vehicle. If shear is critical, then the overload shear capacity for end spans of continuous structures should be enhanced above the theoretical capacity to allow for the actual shear effect being less than for a simply supported span due to the transfer of shear to the interior support.

The above rule for continuous spans is a valid approximation in most cases, where adjacent span lengths are not greatly different. A rigorous analysis will be required in other cases. For example, where a large redistribution of moment from mid-span to supports would be necessary to achieve simultaneous mid-span and support overload moment capacities, the overload moment capacity for the span can be calculated as the mid-span capacity plus the average of the negative moments present at the supports under a loading that would cause the mid-span capacity to be reached.

### 5.4.6 Recommendations for specific cases

Wide bridge decks

The basis of the OPermit algorithm is a single lane or two lane bridge carriageway. OPermit applies the overweight vehicle in one lane and a maximum of one other lane of legal vehicle loading (2 lane bridges). Three or more lanes of traffic loading are not considered.

Eccentricity factors and capacities based on the wide (three or more traffic lanes) structure layout will provide appropriate outcomes for restriction level 3 (crawl central), but will be potentially unconservative for all other restriction levels. There are two options to address this issue.

a) For wide, multiple beam type bridge spans with closely spaced beams (eg Hollowcore units, Super-Tee beams, prestressed I-girders, slabs or steel beams) carrying vehicle traffic in more than two lanes, the eccentricity factors and capacities (MCAP and SCAP) are calculated by adopting a reduced width for the bridge cross-section. This reduced width is based on the width of deck required to support two lanes of traffic (allowing for any structural benefit provided by any shoulders and footpaths). This procedure implicitly makes provision for the possible actual loading of more than one lane of legal vehicles adjacent to the overweight vehicle.

   The application of this recommendation should be backed up by suitable analysis and judgement from an experienced bridge assessment engineer. Adjustment of the Ecentre value may be necessary to maximise the allowable overweight load due to the possible conservatism of this modified approach for restriction level 3 (crawl central). A short statement describing the basis of the calculations must be included in the Comments field (eg 'Structural data based on equivalent 2 lane, 10m wide deck and 4 beams').

   This method does not apply to wide bridge decks where all lanes contribute to the loading of critical elements, such as large box girders or widely spaced girders/trusses with transoms spanning between. These bridge superstructures will require rigorous analysis and data evaluation to allow for traffic in multiple lanes.

b) For the wide bridge layout (for example using the design model), determine MCAP, SCAP and Estd for one lane of HO and one lane of HN loading in the most adverse lane with no load factors. Determine the load in the most critically loaded element.

   Then consider the HO loading in the most adverse lane accompanied by two or more lanes of HN loading with reduction factors applied to the HN loading in accordance with the *Bridge manual* (0.9 for two HN lanes, 0.8 for three, etc).

   Compare the resulting load in the most critically loaded element with the one lane of HN loading above, and increase Estd if necessary.

   Ecentre should be based on an analysis of the wide bridge with only one lane of HO loading.

### Wide, short span bridge structures (eg culverts)

Wide, short span structures (eg short span multi-lane culverts, stock underpasses, pedestrian underpasses or wide slab-type bridges such as short span portal frames) should be analysed as a 3.5m wide (one lane) strip, and the eccentricity factor should be taken as 1.0. This avoids the difficulty of calculating a meaningful eccentricity factor by simply treating the structure as a narrow element supporting a single lane of traffic. This simple method can be conservative for spans exceeding 10m, and for longer spans a more rigorous analysis method should be used.

The structure width shall be defined as 3.5m in the 'width' field of the 'General element' data, with the 'Comments' field to include 'Structure width treated as single lane for analysis purposes'.

### Buried structures (structures with cover)

The live load capacity of buried structures varies depending upon the depth of fill (cover) over the structure. For structures with no cover, the design live load is multiplied by a dynamic load factor (DLF) of 1.30. With 1m cover, the DLF reduces to 1.00. A linear relationship is used between these depths.

The stored structural capacity (ie the actual capacity) within OPermit includes dynamic load effects. However, OPermit does not adjust dynamic load effects to account for overburden depth. This can result in conservative (and restrictive) permitting outcomes.

To address this, buried structures with cover depth between 0-1.0m should be represented with two beam elements, as below. For buried structures with cover depth greater than 1.0m, only element 2 is required.

- Beam element 1 – stored capacity scaled up to allow for full design dynamic allowance (I=1.30 – Impact Code=3).

$$MCAP = \text{Actual MCAP x } \frac{1.30}{\text{DLF for actual cover depth}}$$

  Element is processed in OPermit with impact (Impact Code 3). This element provides enhanced load capacities at high travel speeds, and for a new structure, provides equivalent HN-HO-72 live load capacity at 50km/h (I=1.30).

- Beam element 2 – stored capacity is reduced to exclude dynamic load allowance (I=1.00 – Impact Code=1).

$$MCAP = \text{Actual MCAP x } \frac{1.00}{\text{DLF for actual cover depth}}$$

  Element is processed in OPermit without impact (Impact Code 1). This element ensures that the capacity of the structure is not exceeded at low travel speeds, and reflects that the live load capacity varies based on reduced dynamic allowance with depth.

### Divided carriageway bridges

Bridges with a carriageway divided by a barrier or a raised median kerb restrict the position of an overweight vehicle to the lanes in the direction of travel. The BEAM element can be used to model a divided carriageway bridge by providing an element for each direction, with the direction (increasing or decreasing) specified.

The BEAM element increasing (or decreasing) should have Estd, Ecentre, MCAP and SCAP values determined for the proportional width of bridge deck that carries the lanes in the increasing (or decreasing) direction. The structural data for each BEAM element should be based on a deck width not exceeding 2 lanes – refer to Wide bridge decks, above.

OPermit will process the overweight vehicle permit for the relevant element in the direction of travel only. OPermit will not consider any traffic or heavy vehicles that may be on the opposing direction element.

Where a bypass is available via the opposing lane, this can be notified to the PIO or bridge consultant through a CHECK message.

Shear critical spans

Where shear capacity may be critical and the Estd or Ecentre value for shear is significantly different to that for moment, the recommended approach is to input the BEAM element as two separate BEAM elements: one for moment and one for shear, with different but appropriate Estd and Ecentre values for moment and shear.

- For one BEAM element (moment effects), specify SCAP = 0 (ie shear non-critical).
- For the other BEAM element (shear effects), specify an arbitrary, high MCAP value such that moment effects are never critical. Ensure that the Comments field describes the basis for the data.

Beams with critical sections not located at mid-span or supports

The BEAM element is based on a simply supported beam model, with moment capacity checked at mid-span and shear capacity checked at the ends.

Where bridge spans have critical sections at other than mid-span for moment, or at other than the ends for shear, adjustment of the data is required. A typical case might be a reinforced concrete beam with varying shear and flexural reinforcement, or a post-tensioned continuous structure with flexural–shear interaction effects to be considered at the supports.

For the critical section(s) along the span, calculate the percentage Class capacity as defined in section 7.4.6 of the *Bridge manual*:

$$\text{Class} = \frac{\text{overload capacity} \times 100}{\text{rating load effect}}$$

As the critical section(s) are likely to be moment or shear critical, separate BEAM elements should be input for the span: one for moment (with SCAP = 0) and one for shear (with an arbitrary, large MCAP value to make the moment effect non-critical).

To account for the critical section(s):

- Moment: for the BEAM element MCAP, calculate the overload moment capacity at mid-span and multiply by (critical Class/mid-span Class)
- Shear: for the BEAM element SCAP, calculate the overload shear capacity at the support and multiply by (critical Class/support Class).

If this procedure is used, a statement describing the basis of the data evaluation should be included in the Comments field for the element. This is to avoid future misinterpretation of data.

Beams with differing capacities and class < 100%

Commonly, bridge superstructure configurations comprise reasonably regular beam layouts where the beams have slightly different capacities. A common example is 1930–1950s two lane reinforced concrete T-beam layouts where the external beams have greater capacity than the internal beams. Often these bridges have a low overload capacity with Class < 100%, and it is desirable to provide the maximum overload capacity. For this situation, where the beam layout (spacing) is reasonably consistent and where the capacities are (say) within a range of about 20%, the BEAM element is a suitable method for modelling the bridge span using the procedure outlined below to maximise the available overload capacity.

For irregular beam layouts or beams with greatly differing capacities, it is recommended that the VBEAM element be used.

In the case of beams with slightly differing capacities, to give the correct outcomes MCAP and SCAP would need to be defined as n × overload capacity of the critical beam for the eccentricity factor definition of section 5.4.3 and the algorithm presented in section 5.4.4. This would give rise to the situation where differing values of MCAP and SCAP might be required for 'overweight vehicle central', and also to the situation where the tabulated MCAP and SCAP values could conceivably be greater than the sum of the member overload capacities for the bridge.

To avoid these issues, MCAP and SCAP should be taken as the sum of the actual beam overload capacities, and the eccentricity factor definition modified to give the correct outcome.

Eccentricity factors should be defined for the most critical element (highest ratio of demand to capacity), rather than the most heavily loaded element; this will be as follows:

$$\text{Eccentricity factor} = \frac{\text{total BEAM overload capacity}}{\text{total BEAM rating demand}} \times \frac{\text{critical element rating demand}}{\text{critical element overload capacity}}$$

For further details of how this is implemented in practice, refer to Examples 2 and 3 in section 5.4.8.

### 5.4.7 BEAM element data (Form no. BSD4)

Table 5.4.2 describes the data requirements for the BEAM element. Mandatory fields must be completed and Default fields are provided by OPermit. A number of different BEAM elements may be input for a single bridge.

Table 5.4.2: Input data for the BEAM element

| Form no. BSD4 input data | Specifications | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Bridge Name | See table 5.1.1 | M |
| BSN | See table 5.1.1 | M |
| Direction | See table 5.1.4 | M |
| Type | BEAM | D |
| Description | A brief description of the BEAM element, eg 'PSC Hollowcore beams – Spans 1 & 3'.<br>The maximum number of characters is 255. | M |
| Impact Code | The Impact Code is used to identify the appropriate dynamic load factors to be applied to the element at each restriction level. Applications relevant to BEAM are (see section 4.8):<br>Impact Code – Application<br>1 – Timber<br>3 – Main members other than timber (normal circumstances)<br>4, 5 – Members subjected to abnormally severe impact<br>*continued on following page* | M |

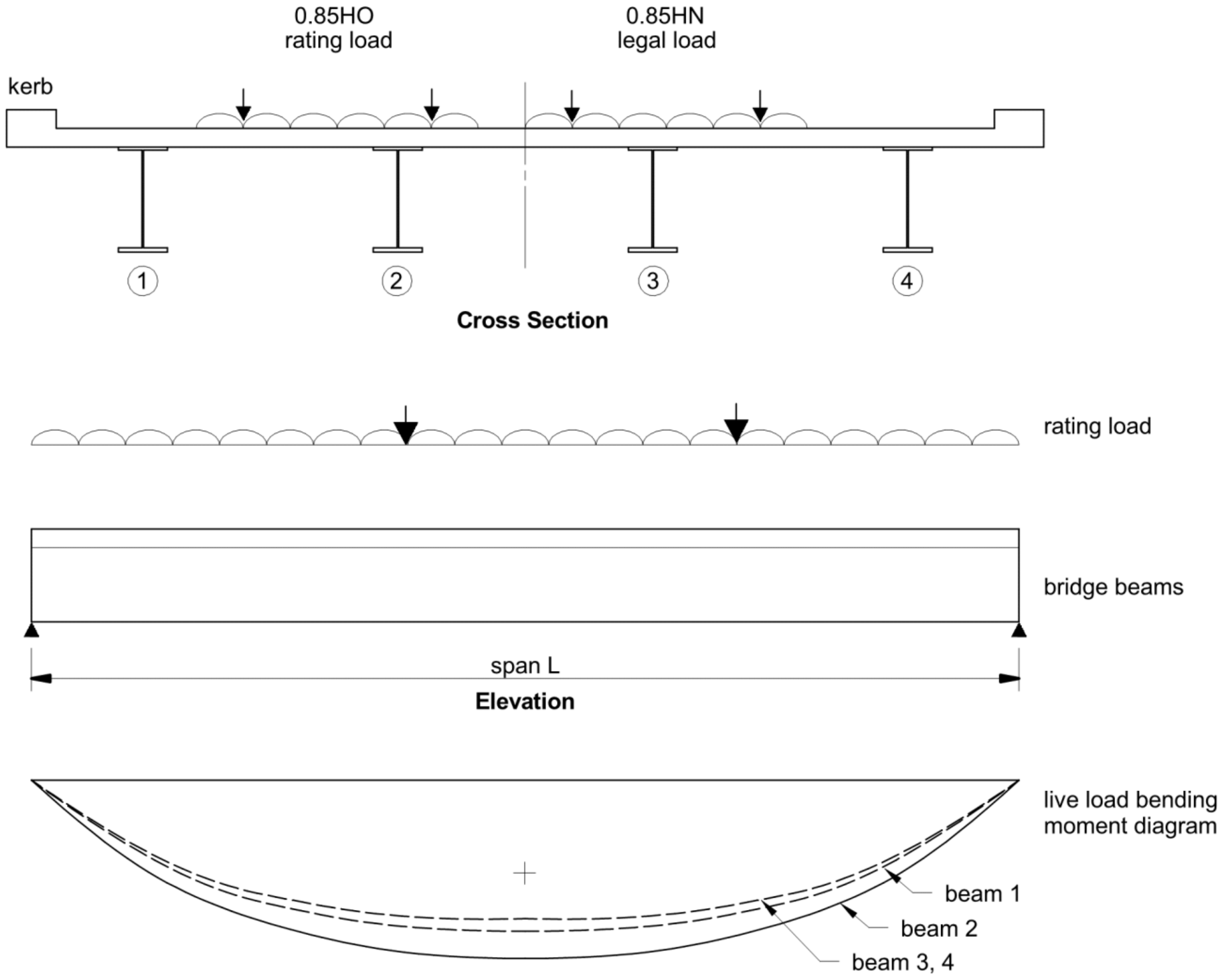
| Form no. BSD4 input data | Specifications | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Estd* | The eccentricity factor for one or two lanes of vehicle loading on the bridge; refer to table 5.4.1. Vehicle loads are located at the extreme offset position within the load lanes to produce the most adverse effects. | M |
| Estd(12)* | The eccentricity factor for an overweight vehicle with one or more axles of type 12 and no axles of type 16, with the overweight vehicle in own lane (or as near as practical), and for bridges of two or more lanes an adjacent lane of legal load.<br>Only populate with specific values for routes with frequent use by vehicles with 12 tyres per axle. Otherwise input zero (0), which defaults to Estd. | M |
| Estd(16)* | The eccentricity factor for an overweight vehicle with one or more axles of type 16 and no axles of type 12, with the overweight vehicle in own lane (or as near as practical), and for bridges of two or more lanes an adjacent lane of legal load.<br>Only populate with specific values for routes with frequent use by vehicles with 16 tyres per axle. Otherwise input zero (0), which defaults to Estd. | M |
| Ecentre* | The eccentricity factor for one lane of vehicle loading central on the bridge, or at another position (defined by RestrictX) that maximises the allowable vehicle load. | M |
| Ecentre(12)* | The eccentricity factor for an overweight vehicle with one or more axles of type 12, and no axles of type 16; central on the bridge or at another position (defined by RestrictX) that maximises the allowable vehicle load.<br>Only populate with specific values for routes with frequent use by vehicles with 12 tyres per axle. Otherwise input zero (0), which defaults to Ecentre. | M |
| Ecentre(16)* | The eccentricity factor for an overweight vehicle with one or more axles of type 16, and no axles of type 12; central on the bridge or at another position (defined by RestrictX) that maximises the allowable vehicle load.<br>Only populate with specific values for routes with frequent use by vehicles with 16 tyres per axle. Otherwise input zero (0), which defaults to Ecentre. | M |
| Span | The longitudinal span of the BEAM element, being the distance between the bearing supports (in metres). | M |
| MCAP** | The overload moment capacity of the BEAM element (in kNm). | M |
| SCAP** | The overload shear capacity of the BEAM element (in kN). | M |
| Comments | Any assumptions made in the calculation of values can be entered. The purpose is to ensure that future review of data recognises any original assumptions made.<br>A 4000 character description may be entered. For example:<br>‘Estd based on deck width for six Super-Tee beams’<br>‘SCAP modified as shear critical section is 1.5m from support’. | O |

* See section 5.4.3, Eccentricity factors.

** See section 5.4.4, Moment and shear capacities.

### 5.4.8 BEAM examples

Example 1: Estd calculation – uniform beam capacities




$M_{MAX}$ = maximum of mid-span moments for beams 1 to 4

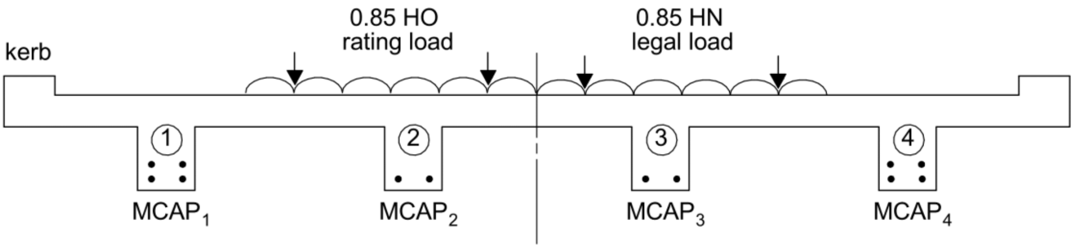
= $M_2$ in this example

$M_{average}$ = average of midspan moments for beams 1 to 4

$= \dfrac{M_1 + M_2 + M_3 + M_4}{4}$ in this example

$$\text{Estd} = \frac{M_{MAX}}{M_{average}}$$

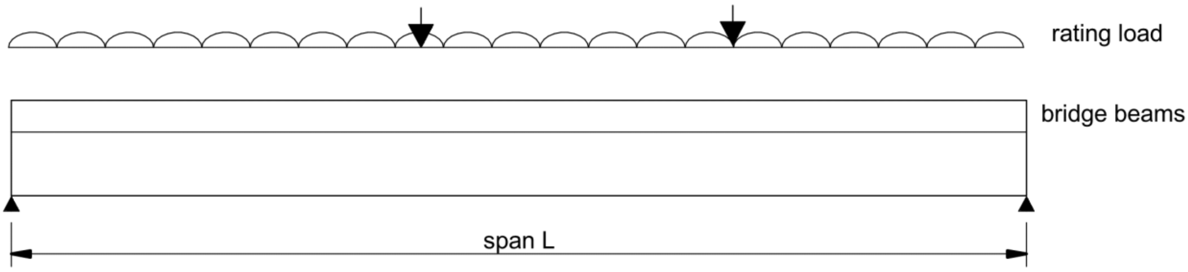
## Example 2: Estd calculation – beams with different capacities and Class < 100%



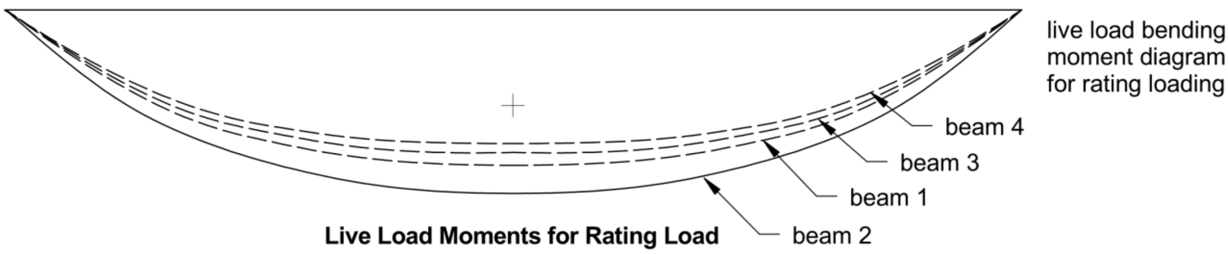

**Cross Section**

Note about transverse load positions:

- Rating load positioned for critical loading of Beam 2 in this example.
- For critical loading of Beam 1, load would be positioned against LH kerb.




**Elevation**




**Live Load Moments for Rating Load**

This method should be used only for the specific cases described in section 5.4.6

$$\text{Estd} = \frac{\text{Total Beam Overload Capacity}}{\text{Total Rating Demand}} \times \frac{\text{Critical Element Rating Demand}}{\text{Critical Element Overload Capacity}}$$

Find critical beam by considering all transverse load positions.

For each position assess $\text{Class}_i = \left(\frac{\text{MCAP}_i}{M_{\text{rating } i}}\right)$ to find minimum Class and therefore critical beam.

For this example where $\text{beam}_2$ is the critical beam:

$\text{MCAP}_1 = \text{MCAP}_4 > \text{MCAP}_2 = \text{MCAP}_3$ wherefore critical beam (minimum Class) = $\text{Beam}_2$

Total Beam Overload Moment Capacity = MCAP = $\text{MCAP}_1 + \text{MCAP}_2 + \text{MCAP}_3 + \text{MCAP}_4$

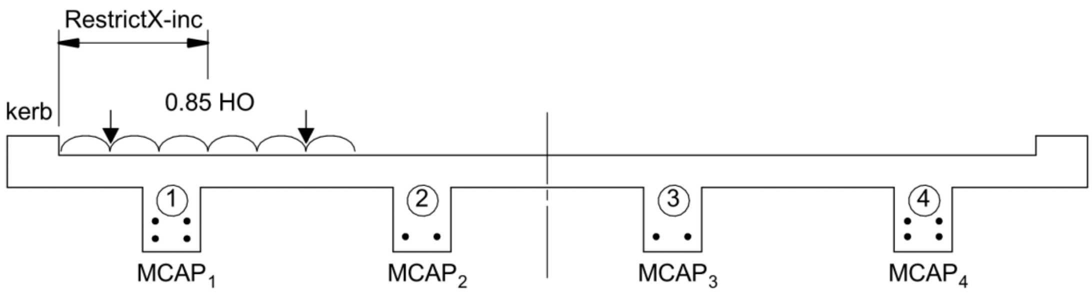
Total Rating Demand = Total Overload Moment = $M_{\text{rating}}$ (for 0.85HO + 0.85HN)

Critical Beam Rating Demand = $M_2$

Critical Beam Overload Capacity = $\text{MCAP}_2$

$$\therefore \text{Estd} = \frac{\text{MCAP}}{M_{\text{rating}}} \times \frac{M_2}{\text{MCAP}_2}$$

## Example 3: Ecentre calculation – beams with different capacities and Class < 100%




Find most favourable vehicle position by considering all transverse load positions.

For each load position assess $Class_i = \left(\frac{MCAP_i}{M_{rating\ i}}\right)$ for each $Beam_i$, to find the critical Class for each load position.

The most favourable vehicle postion will be for the highest value of the critical Class.

$$\text{Ecentre} = \frac{\text{Total Beam Overload Capacity}}{\text{Total Rating Demand}} \times \frac{\text{Critical Element Rating Demand}}{\text{Critical Element Overload Capacity}}$$

For this example :

Total Beam Overload Moment Capacity = MCAP = $MCAP_1 + MCAP_2 + MCAP_3 + MCAP_4$

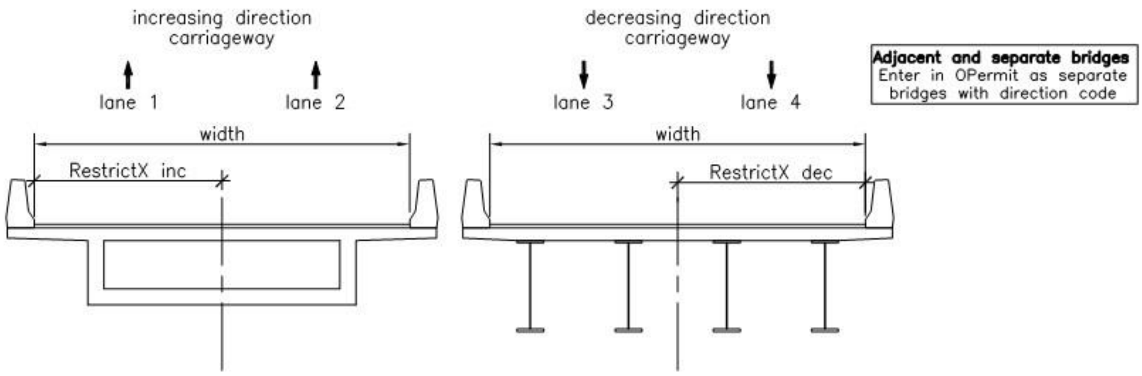
Total Rating Demand = $M_{rating}$ (for 0.85HO only)

Critical Beam Rating Demand = $M_2$ (for 0.85HO only) (*Assuming Beam 2 is critical for the most favourable load position*)

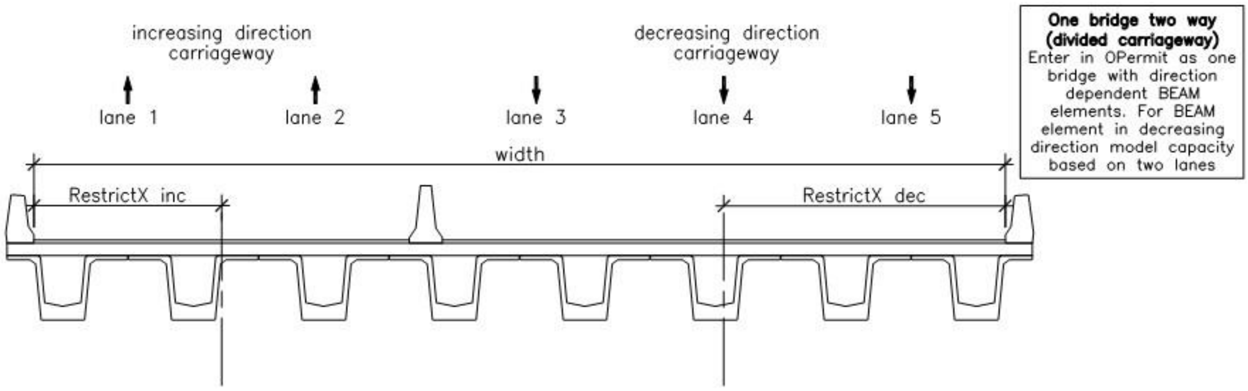
Critical Beam Overload Capacity = $MCAP_2$

$$\therefore \text{Ecentre} = \frac{MCAP}{M_{rating}\ (0.85HO\ only)} \times \frac{M_2\ (0.85HO\ only)}{MCAP_2}$$

Example 4: Typical divided carriageway bridges cross-section



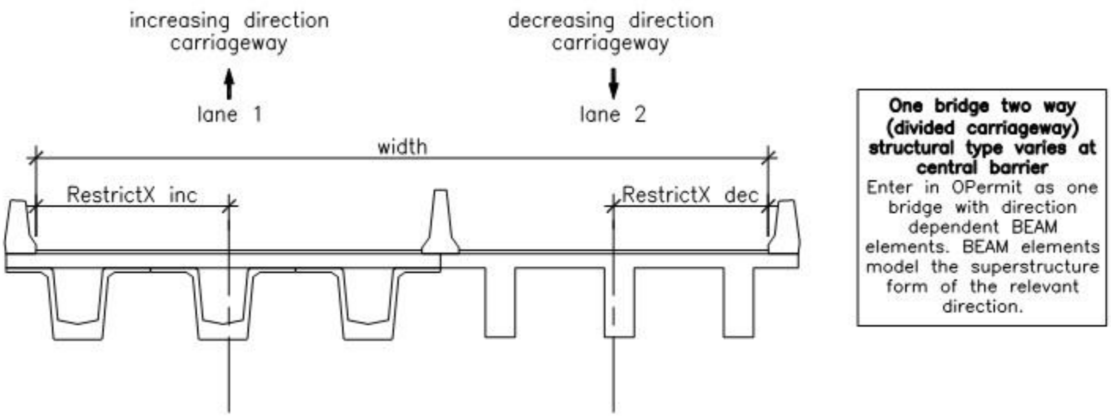

Adjacent Bridges



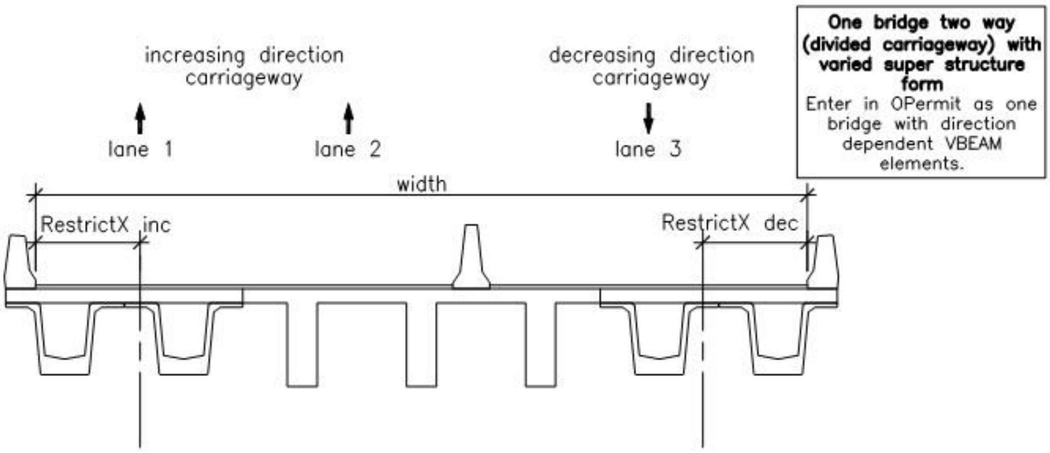

One Bridge (two way)

*continued on following page*

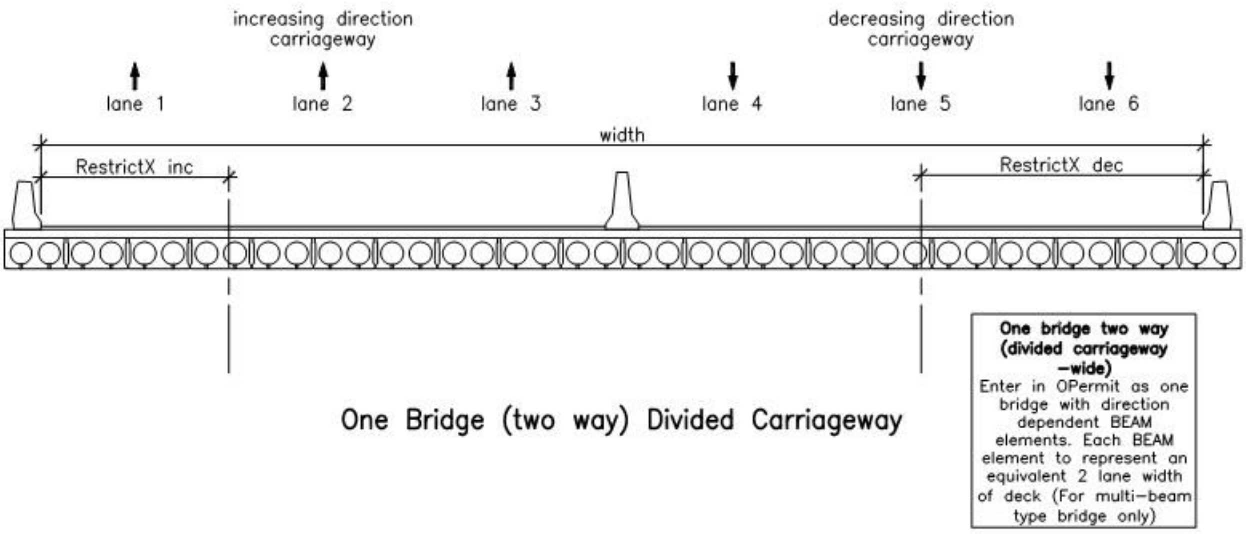
Example 4 (continued): Typical divided carriageway bridges cross-section




One Bridge (two way)

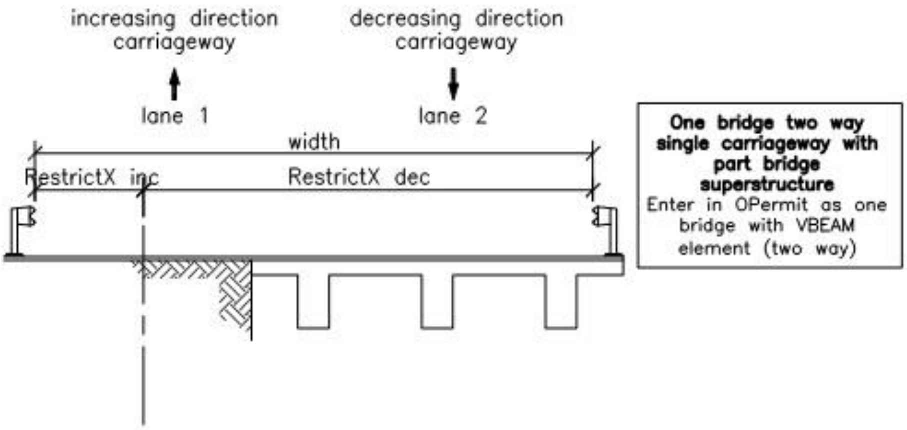



One Bridge (two way)

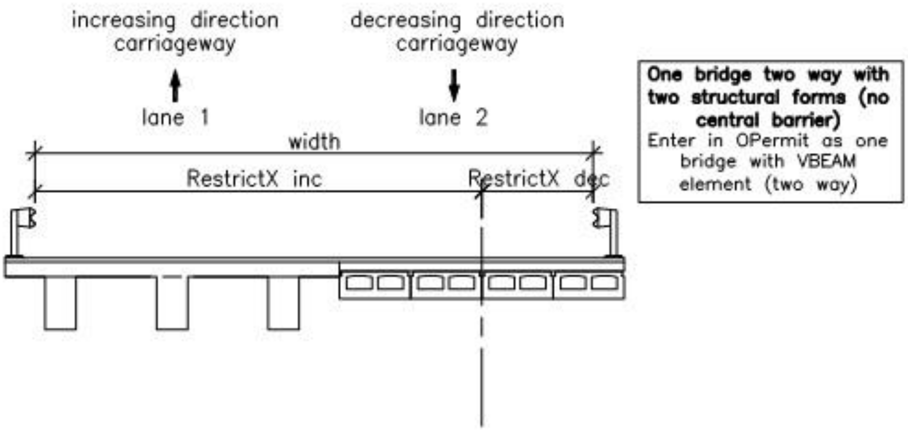



One Bridge (two way) Divided Carriageway

Example 5: Typical two way carriageway bridge cross-sections with different structural forms




One Bridge (two way)




One Bridge (two way)

## 5.5 VBEAM element data

### 5.5.1 VBEAM element overview

The VBEAM element is similar to the BEAM element except that instead of lumping all of the longitudinal beams (or stringers) together and representing them as a single simply supported beam, each beam is considered in its actual position and assigned its own simply supported moment and shear capacities.

This allows VBEAM to model beams with different capacities and with asymmetrical or uneven positioning with respect to the carriageway. It is therefore often used to model widened bridges where the capacity or layout of the widened part of the deck is considerably different from the original part.

The VBEAM element may be used to model all or just part of a bridge cross-section. Two or more VBEAM elements may be used to represent the total cross-section if, for instance, the span lengths of the parts are different, or relative beam stiffness varies significantly – see figure 5.5.4 in section 5.5.4.

To represent bridge decks with a discontinuous cross-section, such as some widened bridge decks or where parts of the cross-section have different spans, discontinuities (zero moment and/or shear capacity) in the transverse structure of the deck are able to be defined.

OPermit calculates the maximum overweight vehicle moment and shear effects on the VBEAM element span. For restriction levels of –1, 0, 1 or 2, an adjacent lane of legal vehicle load (0.85HN × Posting × DLF) is incorporated in combination with the overweight vehicle. For restriction level 3 (crawl central), no other vehicle loads are permitted on the bridge with the overweight vehicle.

OPermit distributes the vehicle wheel loads to the beams using the rules of simple statics. This provides a generally conservative transverse live load distribution of the vehicle loads to the beams, and is described in detail in the following sections.

For each beam, OPermit compares the vehicle's moment and shear with the stored values of overload moment capacity (MCAP) and overload shear capacity (SCAP). Fraction of capacity (FoC) values are output for critical beams, and the reported restriction level is that for which the FoC is the highest but less than 1.0. Descriptions of input data for the VBEAM element are given in table 5.5.1 below.

### 5.5.2 VBEAM element data

The overload moment capacity MCAP (total moment capacity minus permanent load effects) is calculated at the mid-span cross-section for each beam. If other cross-sections within the span are critical, the mid-span MCAP value is modified to allow for this as OPermit only checks mid-span moments.

The overload shear capacity SCAP is calculated for each beam cross-section at the end of the span. If shear is not critical for the span, the value zero may be input and shear will not be checked for the overweight vehicle.

The calculation of the overload capacity $R_o$ is defined in section 7 of the *Bridge manual*.

### 5.5.3 VBEAM element analysis

The VBEAM element uses a simplified analysis based on several parallel simply supported longitudinal beams of the same length.

### Transverse distribution of vehicle wheel loads to beams

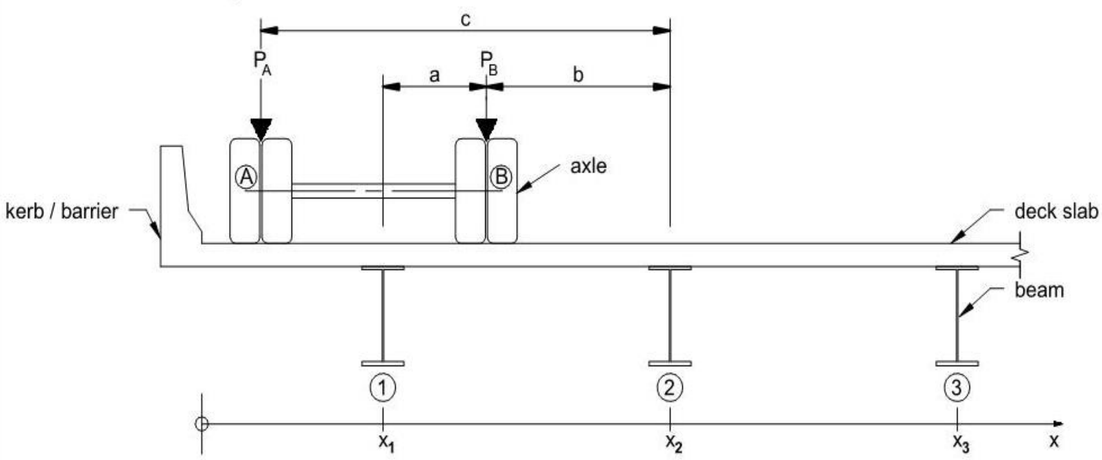
Wheel loads are distributed to the longitudinal beams using the following rules (see figure 5.5.1):

- For interior beams not associated with any discontinuity, the load applied to the interior beam is 0.8 times the simply supported reaction of the deck spanning between the beams.
- The reaction to the first or last (ie exterior) beams, or any beam adjacent to a discontinuity, is taken as the full reaction from the simply supported deck.
- For a deck cantilevering outside the exterior beam, the lever rule is used whereby the moment is calculated for the wheel load on the cantilever about an assumed pin at the first interior beam. The reaction applied to the exterior beam is this moment divided by the distance between the beams.

As a simplification, wheel loads are applied as discrete point loads at the centre of the tyre for single-tyred wheels or at the centre of a dual-tyred (tandem) wheel.

The normal traffic loading of 0.85HN is applied as a 3m wide lane of uniform load plus two axle loads.

Axle loads are assumed to be equally distributed to all wheels on the axle.




$$P_{TOTAL} = P_A + P_B$$

$P_A = P_B$ (axle load equally distributed to wheels)

- Beam ① reaction due to wheel Ⓐ

$$R_{①,A} = P_A \times \frac{c}{(x_2 - x_1)}$$

- Beam ① reaction due to wheel Ⓑ

$$R_{①,B} = P_B \times \frac{b}{(x_2 - x_1)}$$

Total Beam ① reaction is $R_{①,A} + R_{①,B}$

- Beam ② reaction due to wheel Ⓑ

$$R_{②,B} = P_B \times \frac{a}{(x_2 - x_1)} \times 0.80 \quad \text{(interior beam)}$$

Figure 5.5.1: VBEAM element transverse load distribution to beams

## Discontinuities

Discontinuities between longitudinal beams may be applied in several ways (see figures 5.5.2 and 5.5.3):

- If the position of the discontinuity is within ± 0.01m of a beam position, the superstructure at that beam is taken as having a small moment capacity for transverse distribution. In this case the full reaction obtained by treating the deck as simply supported at the longitudinal beams is used at that beam.
- If the discontinuity is positioned between the beams, this is taken to represent a complete break in the superstructure at this point and vehicle loads have no effect across the break.
- If a discontinuity is positioned before the first beam or after the last beam, this determines the full extent of the element and any vehicle load outside these discontinuities does not affect the VBEAM element.

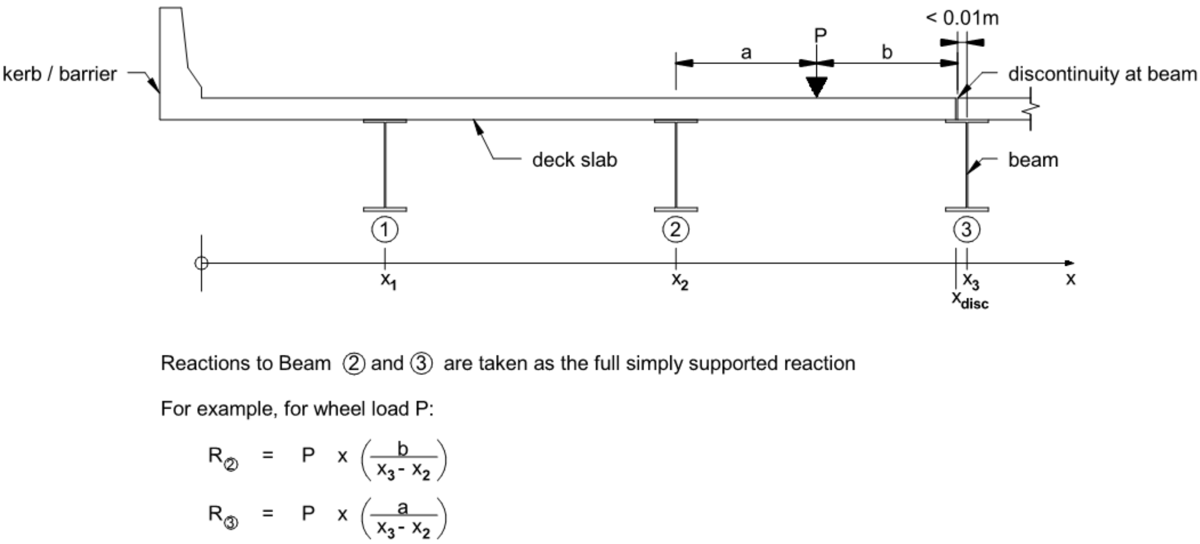



Figure 5.5.2: Discontinuities located at a beam

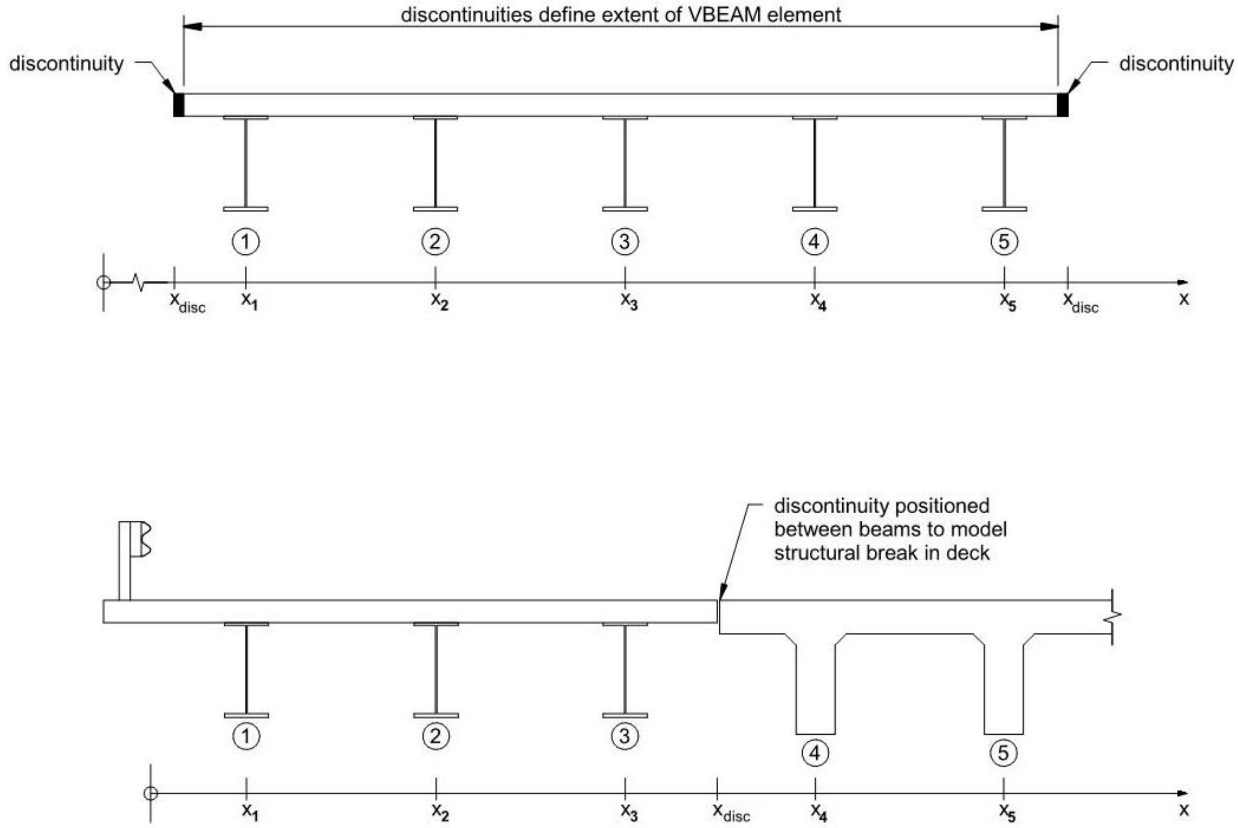



Figure 5.5.3: Positions of discontinuities

Vehicle positioning, RestrictX and calculation of FoC

For restriction levels –1, 0, 1 and 2, calculations are carried out for a range of transverse and longitudinal positions to determine the critical beam. The range of positions is determined by the overweight vehicle and normal lane limits as described in section 4.5. The wheel loads are iterated across the bridge deck in steps of 100mm.

Where an adjacent lane of legal load is applicable (refer to section 4.4), a loading of 0.85HN × DLF × Posting is also applied to the VBEAM element in conjunction with the overweight vehicle load.

Transverse limits for the legal load are as follows.

- For bridges < 10m wide: the kerb face and the carriageway centreline, or the kerb face and the position giving a 0.3m gap between the legal load and the overweight vehicle, whichever gives the least amount of transverse travel.
- For bridges ≥ 10m wide: the kerb face and the position giving a 0.3m gap between the legal load and the overweight vehicle.

For restriction level –1, 0, 1 or 2, VBEAM is an element specific to travel direction for own lane travel and, consequently, different FoC values may be reported for each direction of travel.

For restriction level 3 (crawl central), the overweight vehicle is placed at the specified value of RestrictX (or as close to it as possible based on kerb positions and axle widths), and the distribution of wheel loads to beams is calculated for this position. RestrictX should be specified to locate the overweight vehicle over the beams with the highest capacity, to maximise the overweight capacity of the bridge.

For restriction level 3 no other vehicle is permitted on the bridge with the overweight vehicle.

For divided carriageway bridges with median barriers or kerbs that confine vehicles to one carriageway, RestrictX is specified for each direction of travel on the GENERAL element data form (refer to section 5.1.2).

### 5.5.4 Recommendations for specific cases

Differing span lengths within a cross-section

Where the span lengths of parts of a bridge cross-section are different, VBEAM elements may be positioned adjacent to one another.

Discontinuities positioned before the first beam and after the last beam are used to define the extent of each VBEAM element.

Separate element data sheets are required for each VBEAM element in this situation (see figure 5.5.4).

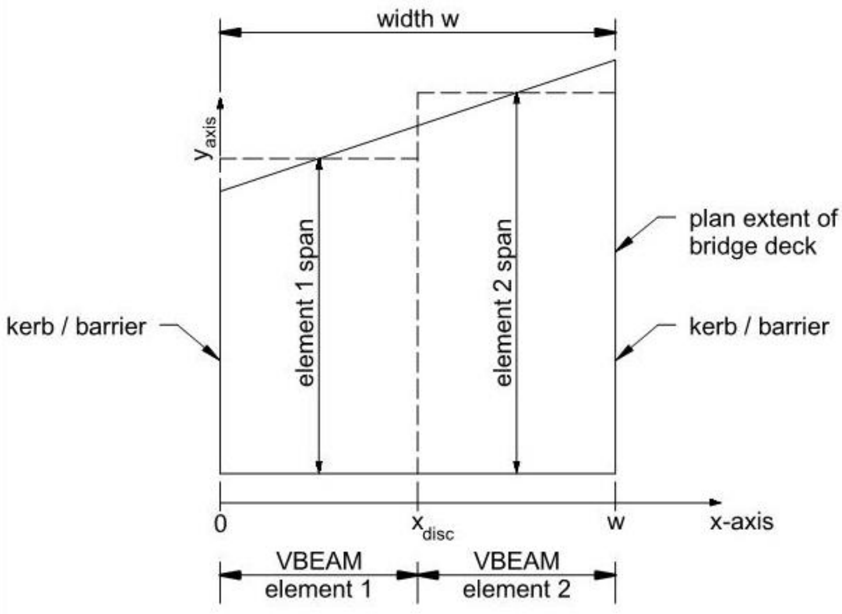



Figure 5.5.4: Two VBEAM elements used to model a skewed bridge deck

Continuous spans or framed spans

The benefit from continuity over the supports is allowed for in a similar fashion to the BEAM element. The procedure to apply to each longitudinal beam is as follows.

- For continuous or framed-in beams, the overload moment capacities at the supports and at mid-span are combined to provide a single capacity (MCAP) equivalent to a simply supported beam.
- Where beams have full moment continuity between spans, are of normal proportions and show no signs of distress, the following simplified procedure may be followed. The overall overload moment capacity of the beam may be converted to that of an equivalent simple span by

subtracting (algebraically) the mid-span positive overload moment capacity from the mean of the two negative overload moment capacities at the supports.

- The overload shear capacity SCAP is calculated for the cross-section at the end of the beam. As above, if shear is not critical for the span, the value zero may be input and shear will not be checked for the overweight vehicle.

The above rule for continuous spans is a valid approximation in most cases, where adjacent span lengths are not greatly different. A rigorous analysis will be required in other cases (see figure 5.4.1).

### Beams of different stiffness

The VBEAM structural model is based on all parallel beams being of a similar stiffness for the distribution of wheel loads to individual beams. Where adjacent beams are not of a similar stiffness, a detailed grillage analysis should be carried out to investigate the load distribution of the bridge superstructure. If appropriate, a discontinuity can be included to separate the beams. Alternatively, separate VBEAM elements may be input to represent the bridge cross-section.

The presence of concrete kerbs may increase the stiffness of the edge beam (refer to the *Bridge manual*); however, the lever rule for edge beams is usually conservative and a grillage model investigation may confirm its adequacy for bridge decks with kerbs.

### Beams with critical sections not at mid-span or at supports

The VBEAM element is based on a simply supported beam model, moment effects are checked at mid-span, and shear effects are checked at the ends.

For those bridge beams with critical sections at other than mid-span for moment, or other than at the ends for shear, data modification is required. Refer to section 5.4.6 for a description of the modifications.

### Widened bridge decks with longitudinal discontinuity near centreline

The VBEAM element uses the 'lever rule' to distribute wheel loads to external beams, or those adjacent to a discontinuity. There are situations where this can be overly conservative, as shown in figure 5.5.5.

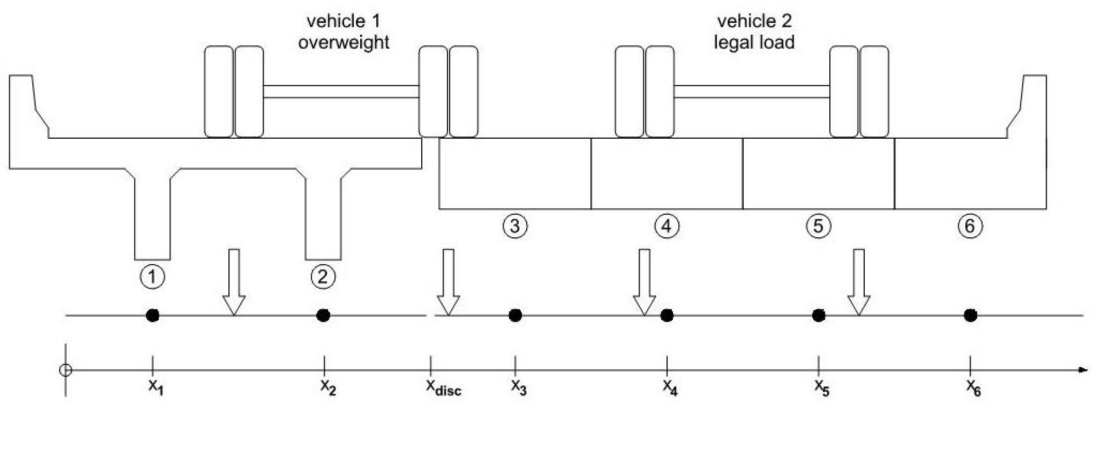



Figure 5.5.5: Longitudinal discontinuity near centreline

The conservatism arises because the VBEAM element is based on a nil transverse load distribution from an external beam (or a beam adjacent to a discontinuity). For bridge decks with sufficient transverse stiffness to transfer load from edge beams to adjacent beams (such as the Hollowcore beams 3 to 6 in figure 5.5.5), VBEAM provides vehicle restrictions that are overly conservative.

In this example, beam 3 is next to a discontinuity and supports wheel loads from both vehicle 1 and vehicle 2. Depending on the dimensions, the VBEAM analysis will allocate to beam 3 more than the full wheel load from vehicle 1 (due to the lever rule) and part of the wheel load from vehicle 2. This may result in unrealistically high effects and thus overly conservative vehicle restrictions.

Methods for dealing with this situation are provided below. They are not suitable for all bridges, and should only be applied on the basis of detailed analysis and judgement by an experienced bridge engineer. If these methods are implemented, a detailed description should be recorded for the element in the Comments field.

Method A – Dummy beam

In this method, a rigorous analysis (eg grillage) is undertaken to identify the maximum effect on a beam adjacent to a discontinuity due to a wheel load positioned adjacent to the discontinuity (see beam 3 in figure 5.5.5). This should be done for both beams adjacent to the discontinuity (ie beams 2 and 3). A VBEAM model is then created that includes two discontinuities and a dummy beam to minimise the conservative analysis of vehicle loading effects (see figure 5.5.6).

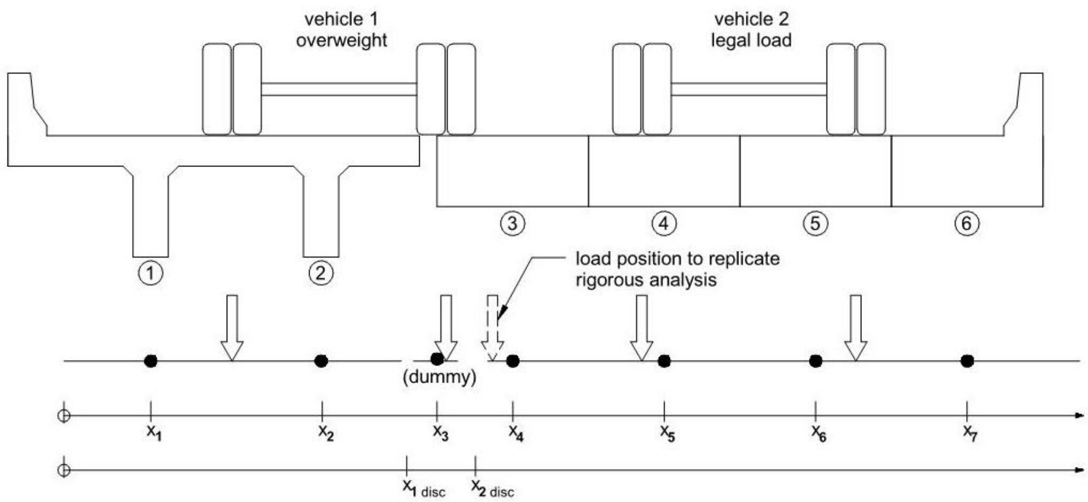



Figure 5.5.6: Modelling bridge with discontinuity near centreline

For example, if the rigorous analysis indicates that the maximum moment or shear effect on beam 3 from vehicle 1's wheel load (P) is equivalent to 1.1P, then:

$$\frac{X5 - X_2DISC}{X5 - X4} = 1.1$$

and hence the position of $X_2$DISC can be determined.

The same process can be used to determine $X_1$DISC based on analysis of beam 2.

The discontinuities to each side of the dummy beam must be greater than 0.01m from the dummy beam position, or from the beams to each side. Given this restriction, the load distribution factor of a wheel to the beam adjacent to the discontinuity will always be greater than 1.0 using this method.

The MCAP value for the dummy beam should be sufficiently high to ensure that it is never critical.

Note that for a single beam with discontinuities on both sides of the beam, VBEAM applies wheel loads positioned between the discontinuities directly to the beam. Torsion (wheel eccentricity) effects are ignored, and as long as the discontinuities are greater than 0.1m away from the beam, or adjacent beams, no load is transferred to adjacent beams.

Method B – Convert VBEAM elements to two or more BEAM elements

The existing VBEAM elements can be converted to BEAM elements that represent different longitudinal superstructure sections. It is not recommended that a single BEAM element be used to model a bridge with variable superstructure, for two reasons. First, the eccentricity calculation will not be accurate for a superstructure with variable sections. Second, the stronger side of the bridge will be penalised in the model as the critical Estd value is based on the lowest individual beam Class.

Generally, superstructure discontinuities tend to exist near the bridge centreline due to widening from one to two lanes. In this case, each independent superstructure section can be modelled as a single BEAM element, with MCAP, SCAP and other parameters corresponding to the relevant section of the superstructure. Estd and Ecentre can then be calculated through detailed analysis and each BEAM element can be set up in one direction only. This method is only suitable where the discontinuity is positioned within about 300mm of the bridge centreline lane marking. In other words, the overweight vehicle must not be supported by the BEAM element in the adjacent lane.

### 5.5.5 VBEAM element data (Form no. BSD5)

Table 5.5.1 describes the data requirements for the VBEAM element. Mandatory fields must be completed and Default fields are provided by OPermit. A number of different VBEAM elements may be input for a single bridge.

### 5.5.6 VBEAM examples

VBEAM examples will be posted on the Transport Agency website as they become available. Please check the webpage of this guide, which may be accessed via www.nzta.govt.nz/resources.

Table 5.5.1: Input data for the VBEAM element

| Form no. BSD5 input data | Specifications | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Bridge Name | See table 5.1.1 | M |
| BSN | See table 5.1.1 | M |
| Direction | See table 5.1.4 | M |
| Type | VBEAM | D |
| Description | A brief description of the VBEAM element, eg 'Old 2 beam RC bridge widened with 11 PSC units'.<br>The maximum number of characters is 255. | M |
| Impact Code | The Impact Code is used to identify the appropriate dynamic load factors to be applied to the element at each restriction level. Applications relevant to VBEAM are as follows (refer to section 4.8):<br>Impact Code – Application<br>1 – Timber<br>3 – Main members other than timber (normal circumstances)<br>4, 5 – Members subjected to abnormally severe impact | M |
| Span | The longitudinal span of the VBEAM element, being the distance between the bearing supports (in metres). | M |
| NBeams | The number of longitudinal beams comprising the VBEAM element. | M |
| NDisc | The number of discontinuities (may be zero). | M |
| MCAP1, MCAP2, etc | The overload moment capacity of each beam within the VBEAM element (in kNm). Record as MCAP1, MCAP2, MCAP3, etc for beams 1, 2, 3, etc respectively. | M |
| SCAP1, SCAP2, etc | The overload shear capacity of each beam within the VBEAM element (in kN). If input as zero (0), shear is assumed not to be critical. Record as SCAP1, SCAP2, etc for beams 1, 2, 3, etc respectively. | M |
| XPosition | The position (in metres) of each of the beams (at the beam centreline) from the left-hand kerb or barrier (when looking in the increasing highway direction). Beams must be more than 0.1m apart. Record as x1, x2, x3, etc for beams 1, 2, 3, etc respectively.<br>$x = 0$ is the road side of the left-hand kerb or barrier. | M |
| Position of Discontinuities | The position of each of the discontinuities (in metres) from the left-hand kerb or guard rail (when looking in the increasing highway direction). Discontinuities must be more than 0.1m apart. | M |
| Comments | Any assumptions made in the calculation of values can be entered. The purpose is to ensure that future review of data recognises any original assumptions made.<br>The maximum number of characters is 4000. | O |

# 5.6 TRANSOM element data

## 5.6.1 TRANSOM element overview

The TRANSOM element is used for bridges with transoms. Transoms are transverse spanning beams which support longitudinal stringers or decks and are in turn supported by two longitudinal beams. The centreline of the carriageway is assumed to coincide with the centreline of the supporting beam system. An example of this arrangement is shown in figure 5.6.1.

The TRANSOM element only models the transom member between the two transom support beams. Any cantilevered portion of transom outside the transom support beams should be modelled using the INFLUENCE element (see example 4 in section 5.7.3).

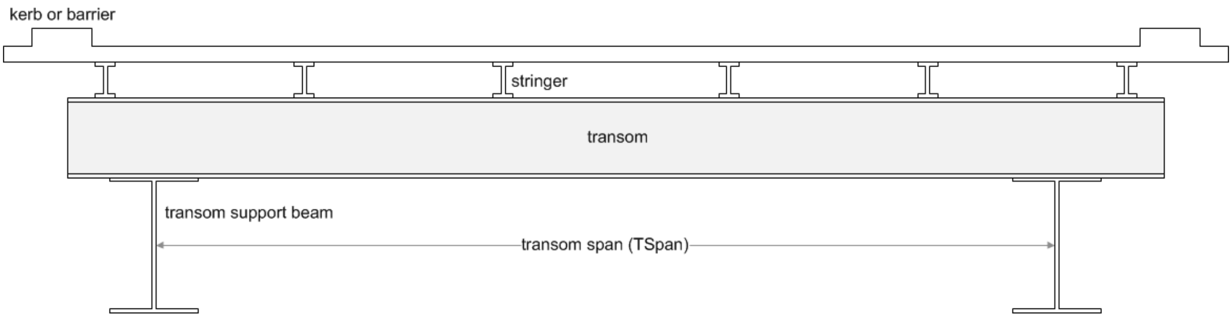



Figure 5.6.1: Typical transom arrangement

The vehicle load acting on each stringer span is transversely distributed by the deck to the stringers. The stringers then transfer the load to the transom as individual reactions. Both the transom and the stringers are considered to be simply supported, with spans of TSpan (figure 5.6.1) and SSpan (figure 5.6.2) respectively. To simplify the load distribution process, TRANSOM assumes that the load on the transom acts through the vehicle axle closest to the transom, and that each wheel on that axle is equally loaded.

The TRANSOM element uses a two-stage approach to calculate the maximum shear and moment effects.

- In the first stage, TRANSOM incrementally moves the overweight vehicle along two adjacent stringer spans (figure 5.6.2) until the peak reaction ($R_a + R_b$) is obtained. The axle closest to the transom for the vehicle position causing the maximum load effect is the critical axle used in the second stage. This axle may be different for moment and shear. In some scenarios, the axle to be used in the second stage of calculation may differ for each restriction level. The system considers all possible critical axles for load effects within 20% of the maximum load effect.

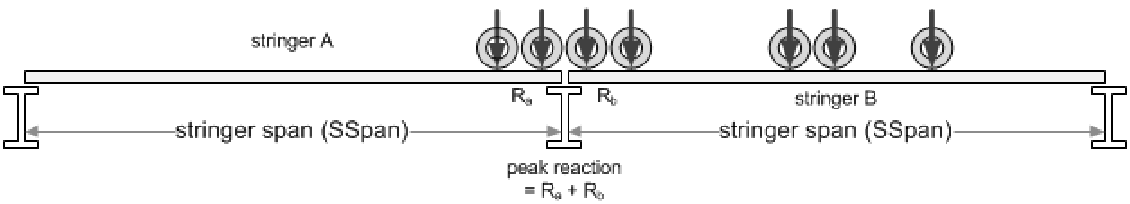



Figure 5.6.2: Calculating maximum load on transom

- In the second stage, the peak reaction on the transom from the overweight vehicle is distributed across the critical axle, and along with the adjacent legal vehicle load (0.85HN if there are two lanes) is incrementally moved (in 100mm increments) from kerb to kerb and the maximum transom shear and moment are calculated (figure 5.6.3). Dynamic load factors are then applied for each restriction level at each position, and the maximum moment and shear are compared with the stored MCAP and SCAP values to obtain fraction of capacity (FoC) values. The reported restriction is that for which the FoC is the highest but less than 1.0.

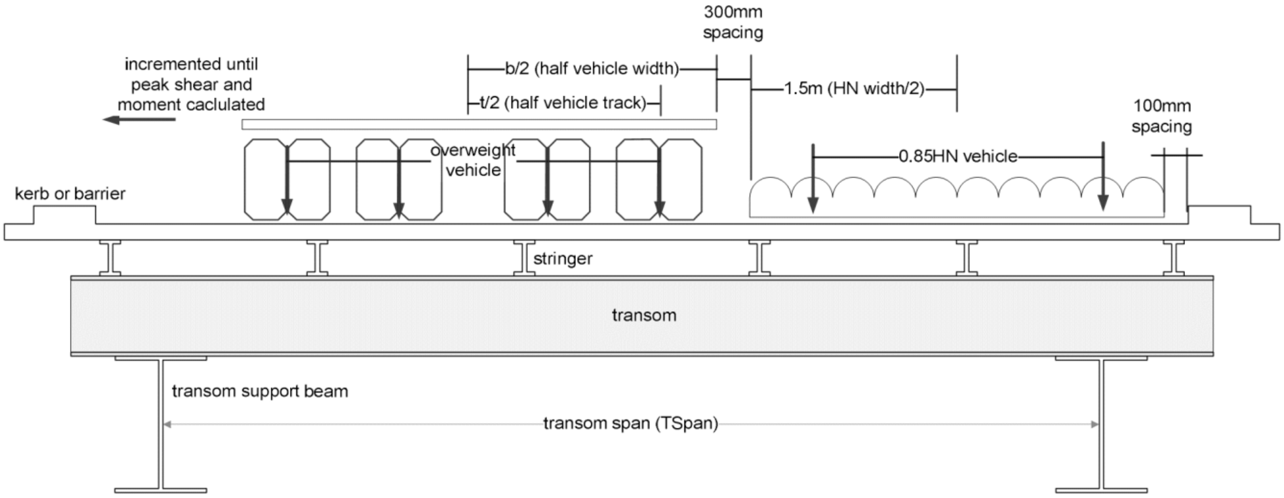



Figure 5.6.3: Calculating maximum transom moment and shear

## 5.6.2 TRANSOM element data (Form no. BSD6)

Table 5.6.1 describes the data requirements for the TRANSOM element. Mandatory fields must be completed and Default fields are provided by OPermit.

Table 5.6.1: Input data for the TRANSOM element

| Form no. BSD6 input data | Specifications | Mandatory (M)/ Default (D)/ Optional (O) |
|---|---|---|
| Bridge Name | See table 5.1.1 | M |
| BSN | See table 5.1.1 | M |
| Direction | See table 5.1.4 | M |
| Type | TRANSOM | D |
| Description | A brief description of the TRANSOM element, eg 'Transoms spans 1 to 4'.<br>The maximum number of characters is 255. | M |
| Impact Code | The Impact Code is used to identify the appropriate dynamic load factors to be applied to the element at each restriction level. Applications are generally as follows (refer to section 4.8):<br>Impact Code — Application<br>1 — Timber<br>3 — Main members other than timber (normal circumstances)<br>4, 5 — Members subjected to abnormally severe impact | M |
| TSpan | Length of the transom between supports (in metres). | M |
| SSpan | Length of the stringer/deck between transom supports (in metres). | M |
| MCAP | Overload moment capacity of the midspan zone of the transom (in kNm). | M |
| SCAP | Overload shear capacity of the end zones (support area) of the transom (in kN). If stored as zero (0), then shear is assumed to be not critical. | M |
| Comments | Comments may be provided to elaborate on any assumptions or relevant issues or information affecting the development of data which may be important for future reference.<br>The maximum number of characters is 4000. | O |

### 5.6.3 TRANSOM example

Example: Steel truss bridge transoms

A single lane steel truss bridge has a carriageway width (w) of 4.0m, a transom span of 5.0m and a stringer span of 7.0m. The overweight vehicle comprises a trailer with 5 axles, each at 1.0m spacing. Each axle is twin-tyred (600mm wide) and loaded to 14 tonnes.

Structural input data

| | |
|---|---|
| Type | = Transom |
| Description | = 'Transoms span 1' |
| Impact Code | = 3 |
| Transom span (TSpan) | = 5.0m |
| Stringer span (SSpan) | = 7.0m |
| MCAP | = 600kNm |
| SCAP | = 500kN |

(Note that MCAP and SCAP are the overload capacities, ie the total moment and shear capacities minus the permanent load effects.)

OPermit analysis

By inspection, the maximum reaction on the transom occurs when the centre wheel is located over the transom (figure 5.6.4).

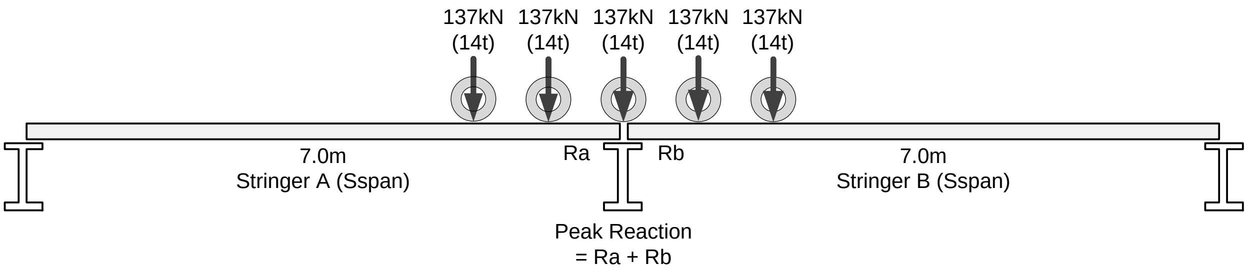



Figure 5.6.4: Calculating peak reaction on the transom

$$\text{Peak reaction} = 2/7 \times (11 \times 137) + 137 = 567.6\text{kN}$$

A simplified model of the load on the transom is shown in figure 5.6.5. The axle load comprises two UDLs (uniformly distributed loads) from each wheel. The UDL for each wheel is calculated as follows:

Equivalent wheel UDL on transom = $(567.6/2) \div 0.6 = 473\text{kN/m}$ over the 600mm width of the wheel

A. Shear analysis

Peak shear on the transom is:

$$\text{Shear at } R_m = \frac{0.6 \times 473 \times (4.2 + 2.3)}{5.0} = 368.94\text{kN}$$

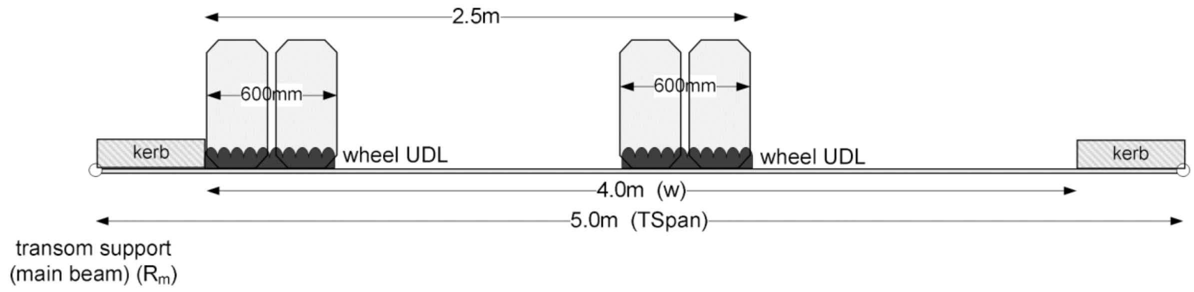



Figure 5.6.5: Calculating maximum shear on the transom

As the vehicle is own lane and unrestricted (restriction level –1), the dynamic load factor is 1.43. The factored peak shear is therefore 368.94 × 1.43 = 527.6kN. As the SCAP = 500kN, the vehicle's restriction level is increased to level 0 (50km/h own lane), which reduces the dynamic load factor to 1.3. The FoC is therefore:

$$\text{FoC} = 368.94 \times 1.3/500 = 0.96$$

This is a 'pass', but only at 50km/h own lane.

B. Moment analysis

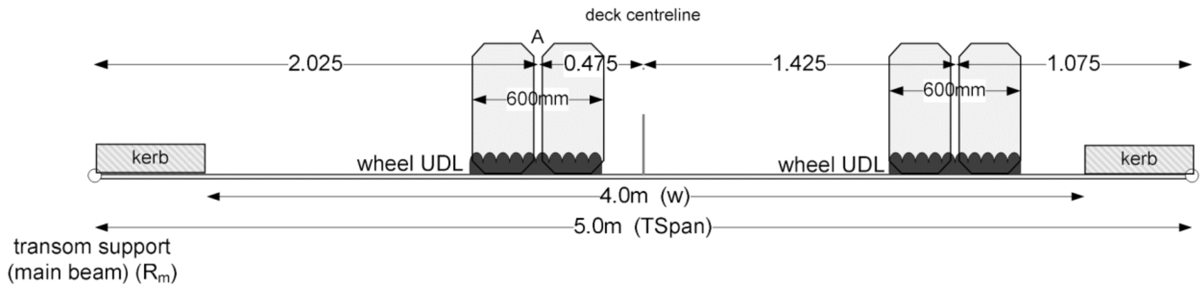



Figure 5.6.6: Calculating maximum moment on the transom

Figure 5.6.6 details the position of maximum moment for the transom. (This is determined by OPermit moving the load incrementally along the transom.) The peak moment on the transom is therefore:

$$\text{Peak moment at A} = R_m \times 2.025 - 473 \times 0.3 \times 0.15$$

$$\text{where } R_m = \frac{473 \times 0.6(2.975 + 1.075)}{5.0} = 229.9\text{kN}$$

$$\text{Therefore: peak moment at A} = 465.5 - 21.3 = 444.2\text{kNm}$$

As the vehicle is own lane and unrestricted, the dynamic load factor is 1.43. The factored peak moment is therefore 444.2 × 1.43 = 635.2kN. As the MCAP = 600kN, the vehicle's restriction level is increased to level 0 (50km/h own lane), which reduces the dynamic load factor to 1.3. Then:

$$\text{FoC} = 444.2 \times 1.3/600 = 0.96$$

The vehicle may therefore cross, but only at 50km/h own lane.

# 5.7 INFLUENCE element data

## 5.7.1 INFLUENCE element overview

The INFLUENCE element can be used to model unusual bridges or bridge components where the other element types do not provide an adequate representation of structural behaviour. This element provides a versatile means of modelling bridge components for a variety of actions. Examples of these bridge or component types include:

- bridges where the critical section cannot be modelled by other elements
- cantilevered spans or supporting members
- load critical pier caps
- load critical columns, piles, struts, etc
- bridges with unusual discontinuities or variable construction depths
- cantilevered transom elements
- curved bridges where torsion is the critical effect.

The INFLUENCE element relies on a thorough understanding of the critical components or features and is used to model the effect of vehicles on those components. This requires a good understanding of the relationship of the vehicle position to the load effect at the critical component section. Note that the INFLUENCE element applies to a fixed point on the bridge and to only one load effect (eg only moment or only shear, etc).

INFLUENCE elements are used in a similar manner to the BEAM element, except that instead of calculating the vehicle effects on a simply supported span, the effect is determined from a longitudinal influence line.

As an influence line applies to a fixed point on a bridge and to only one effect (eg either moment or shear), only one capacity is stored for comparison. A number of different INFLUENCE elements may be input for a single bridge, with a separate data entry form for each one.

Two scale factors are provided – one for the overweight vehicle in its own lane (Bstd) and one for it travelling in the central position (Bcentre). When calculating Bstd, it is important to note that OPermit only applies one lane of loading (the overweight vehicle). If two lanes of loading affect the critical component (the overweight vehicle in one lane and normal (legal) loading in the other lane), then Bstd must be adjusted. Refer to example 3 below.

The basic load effect at the critical section is calculated by OPermit incrementally moving the overweight vehicle along the influence line. It does this in the increasing and decreasing directions. Each axle load is multiplied by the corresponding influence line coefficient. For each incremental vehicle position, the total action for all axles is summed and this is multiplied by the dynamic load factor and Bstd or Bcentre to obtain the factored load effect. The maximum value of the factored load effect for all incremental vehicle positions is divided by CAPAC (see table 5.7.1) to obtain the fraction of capacity (FoC). The reported restriction level is that for which the FoC is the highest but less than 1.0.

The influence line coefficients are positive where the axle loading causes an increase in the load effect, and negative where the axle loading causes a reduction in (relieves) the load effect. Hence, the critical load effect is always positive for comparison with the CAPAC value, which is always positive. Should a net negative load effect result for any particular vehicle position, a FoC is not calculated. Care needs to be exercised when using INFLUENCE elements to represent conventional negative load effects. For example, when calculating cantilevered beam moments at a pier (usually represented as negative load effects), use positive coefficients to ensure that the moment effects are positive. Where the coefficient for part of an influence line is negative, the benefit of this relieving effect is included in the load effect calculation.

## 5.7.2 INFLUENCE element data (Form no. BSD7)

Table 5.7.1 describes the data requirements for the INFLUENCE element. Mandatory fields must be completed and Default fields are provided by OPermit.

Table 5.7.1: Input data for the INFLUENCE element

| Form no. BSD7 input data | Specifications | Mandatory (M) / Default (D) / Optional (O) |
|---|---|---|
| Bridge Name | See table 5.1.1 | M |
| BSN | See table 5.1.1 | M |
| Direction | See table 5.1.4 | M |
| Type | INFLUENCE | D |
| Influence Element no. | Provides details of the element number where several INFLUENCE elements are used for the same bridge (eg 2 of 3). | M |
| Description | A brief description of the component that has been modelled, eg 'Pier Cap supporting spans 2 and 3' or 'Hogging moment of pier 2'.<br>The maximum number of characters is 255. | M |
| Impact Code | The Impact Code is used to identify the appropriate dynamic load factors to be applied to the element at each restriction level. Applications are generally as follows (refer to section 4.8):<br>Impact Code – Application<br>1 – Timber<br>2 – Concrete deck slabs<br>3 – Main members other than timber (normal circumstances)<br>4, 5 – Members subjected to abnormally severe impact<br>The dynamic load factor (DLF) applicable to the restriction level being considered is calculated using the stored value for YLength (see below). | M |
| Stress Number | Identifies the overload effect being represented by the INFLUENCE element.<br>Stress number – Overload effect<br>1 – Moment or torsion (in kNm)<br>2 – Shear or torsion/compression (in kN)<br>*continued on following page* | M |

| Form no. BSD7 input data | Specifications | Mandatory (M)/ Default (D)/ Optional (O) |
|---|---|---|
| Bstd | Bstd is the scale factor for the overweight vehicle when it is travelling in its own lane. Bstd is used to convert the aggregated value of the influence line coefficient multiplied by each axle load, to the actual load effect in the critical element.<br>Note that OPermit only applies one lane of loading (the actual overweight vehicle load). If for the critical component it is necessary to account for two or more lanes of loading (the overweight vehicle in one lane and normal (legal) loading in the other lanes), then this should be accounted for by adjusting Bstd accordingly. Refer to example 3 below. | M |
| Bstd(12) | Bstd(12) has the same function as Bstd but is used by OPermit for vehicles with 12 tyres per axle. Bstd(12) should only be determined for routes with relatively frequent use by wide, 12-tyred axles and where the Bstd value is deemed to be overly conservative. For all other bridges, zero (0) should be input and this defaults to Bstd. | M |
| Bstd(16) | The same function and data requirements as Bstd(12), but applicable to vehicles with 16 tyres per axle. | M |
| Bcentre | Bcentre is the scale factor for when the vehicle is travelling centrally. | M |
| Bcentre(12) | Bcentre(12) has the same function as Bcentre but is used by OPermit for vehicles with 12 tyres per axle. Bcentre(12) should only be determined for routes with relatively frequent use by wide, 12-tyred axles and where the Bcentre value is deemed to be overly conservative. For all other bridges, zero (0) should be input and this defaults to Bcentre. | M |
| Bcentre(16) | The same function and data requirements as Bcentre(12), but applicable to vehicles with 16 tyres per axle. | M |
| YLength | Span length (in metres) for calculating the dynamic load factor. | M |
| CAPAC | The overload capacity of the member (in kNm or kN) as it relates to the Stress Number, ie total capacity minus dead load and other permanent load effects. CAPAC must have a positive value. | M |
| Number (n) | Number of ordinates on the influence line. Must equal the same number of completed rows in the Influence Line data table (ie $y_n$) | M |
| YPosition<br>$\{y_1, y_2 \ldots y_n\}$ | Influence line position ordinates (in metres) from an arbitrary origin, in the longitudinal direction along the bridge deck. | M |
| Influence Coefficient<br>$\{s_1, s_2 \ldots s_n\}$ | Influence line coefficients corresponding to the position ordinates $\{y_1, y_2 \ldots y_n\}$ in the longitudinal direction along the bridge deck (in kNm/kN or kN/kN).<br>The coefficients shall be positive where the axle loading causes an increased load effect and negative where the axle loading decreases (relieves) the load effect. | M |
| Comments | Comments may be provided to elaborate on any assumptions or relevant issues or information affecting the development of data which may be important for future reference.<br>The maximum number of characters is 4000. | O |

### 5.7.3 INFLUENCE examples

Example 1: Moment capacity at extremely critical beam section

This example is for a continuous single lane span with varying cross-section, where the moment capacity at the mid-span section is extremely critical, and where the simplified BEAM element is not considered to adequately represent the criticality.

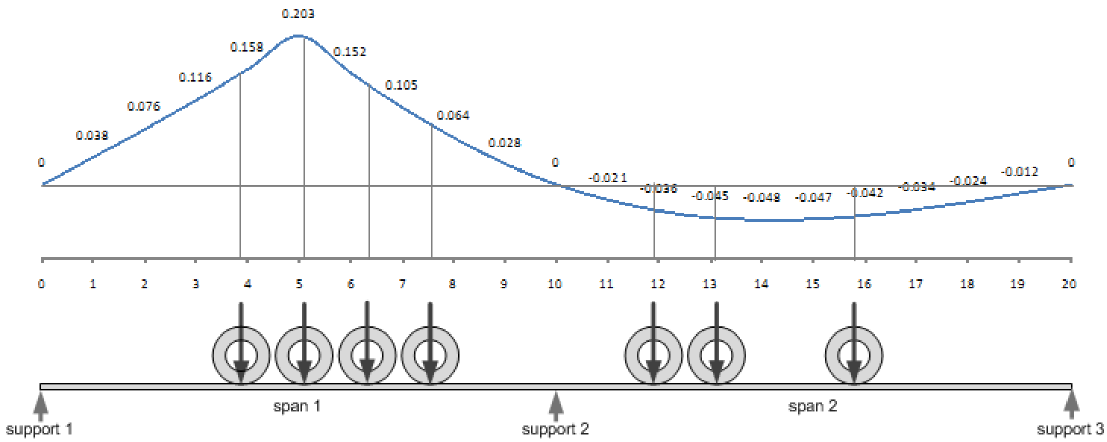



Figure 5.7.1: Example influence line for the mid-span moment of span 1

Using a 1kN load, the influence line coefficients are obtained in the normal manner to represent the moment effect (kNm) at the midpoint of span 1 for a load at any point on the bridge.

OPermit moves the vehicle along the influence line. At each incremental vehicle position, each axle mass is multiplied by the ordinate value on the influence line (see example in table 5.7.2). The sum for all axles represents the basic load effect at the critical point represented by the influence line (in this case, the centre of span 1). Once the maximum value of the load effect has been determined for all vehicle positions, it is then multiplied by Bstd or Bcentre and the dynamic load factor to obtain the maximum factored load effect. The maximum factored load effect is then compared with CAPAC to obtain the fraction of capacity (FoC).

Table 5.7.2: Influence line analysis, Example 1

| Axle | Axle position, y (m) | Axle mass (kN) | Ordinate, s (kNm/kN) | Action from each axle (kNm) |
|---|---|---|---|---|
| 1 | 3.8 | 120 | 0.1496 | 17.952 |
| 2 | 5.05 | 120 | 0.20045 | 24.054 |
| 3 | 6.3 | 120 | 0.1379 | 16.548 |
| 4 | 7.5 | 120 | 0.0845 | 10.14 |
| 5 | 11.99 | 80 | −0.03585 | −2.868 |
| 6 | 13.05 | 80 | −0.04515 | −3.612 |
| 7 | 15.8 | 60 | −0.043 | −2.58 |
| | | | Total action | 59.63 kNm |

For this example Bstd is 1.9, the dynamic load factor (DLF) is 1.3 and the CAPAC of the beam at the centre of span 1 is 160kNm. If the result in table 5.7.2 is the maximum basic load effect for all vehicle positions, then the FoC would be 0.92 [(Bstd × DLF × action)/CAPAC]. The vehicle could therefore pass in own lane for the assessed restriction level.

Example 2: Shear capacity at root of cantilevered support beam

This example comprises a single lane cantilevered support beam supporting a suspended span. The INFLUENCE element is used to model the shear effect at the cantilever support.

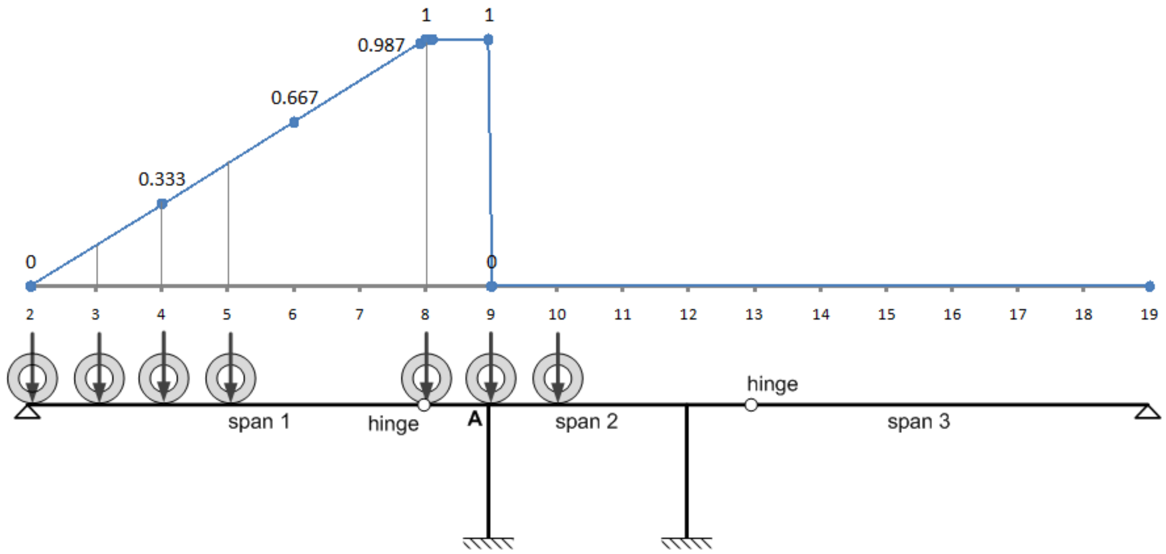



Figure 5.7.2: Example influence line for shear at cantilever support (A)

Table 5.7.3: Influence line analysis, Example 2

| Axle | Axle position, y (m) | Axle mass (kN) | Ordinate, s (kN/kN) | Action from each axle (kN) |
|---|---|---|---|---|
| 1 | 2 | 120 | 0 | 0 |
| 2 | 3 | 120 | 0.167 | 20.04 |
| 3 | 4 | 120 | 0.333 | 39.96 |
| 4 | 5 | 120 | 0.5 | 60.0 |
| 5 | 8 | 80 | 1.0 | 80.0 |
| 6 | 9 | 80 | 1.0 | 80.0 |
| | | | Total action | 279.7 kN |

For this example Bstd is 1.65, the dynamic load factor is 1.3 and the CAPAC (overload shear capacity) of the beam at cantilever support A is 537kN. The factored load effect is 1.65 × 1.3 × 279.7 = 600.0kNm. If the result derived from table 5.7.3 is the most critical for all the vehicle positions, then the FoC for unrestricted travel would be 1.12 (600/537). The INFLUENCE element would therefore be re-run at a lower restriction level and travel restrictions would apply.

### Example 3: Critical two lane truss hanger

The following example is for a vertical hanger in a simple two lane pin-jointed truss. Figure 5.7.3 shows the influence line for this case. Because the bridge has two lanes, careful consideration must be given to the calculation of Bstd.

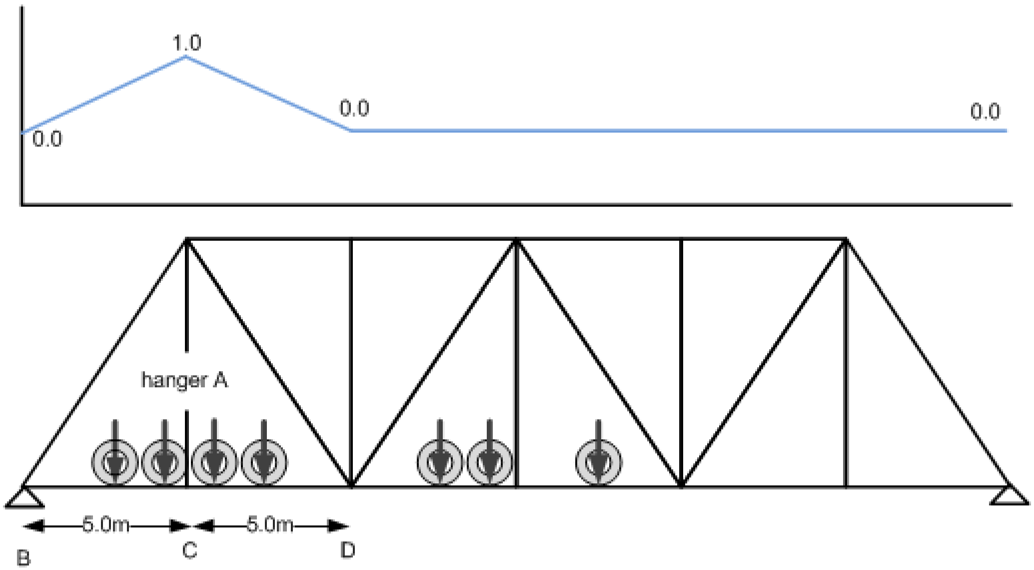



Figure 5.7.3: Example influence line for the axial load on hanger A

Transoms are located at 5m centres, and support stringers. A simplified cross-sectional view of one such transom is provided in figure 5.7.4.

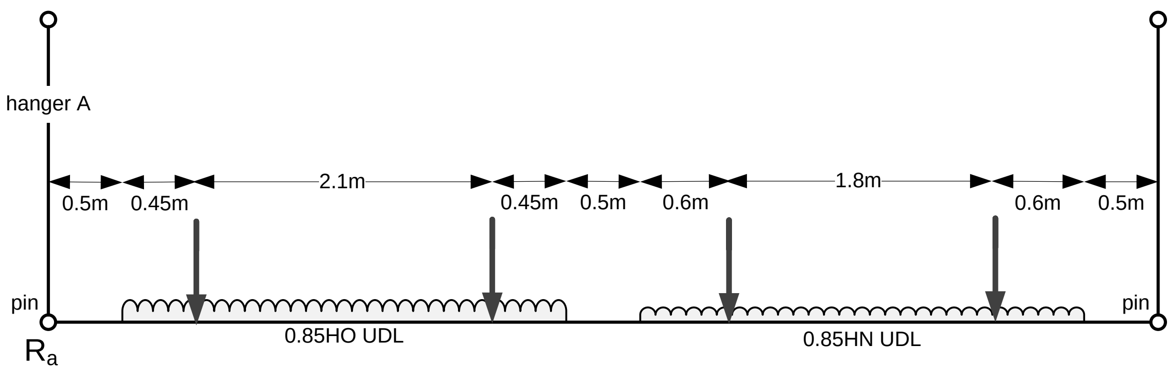



Figure 5.7.4: Simplified model at transom C

Bstd needs to account for both the overweight vehicle in one lane and normal (legal) vehicles in the adjacent lane. This is done by considering loadings of 0.85HO in one lane and 0.85HN in the adjacent lane. While this may result in some inaccuracy for the actual overweight vehicle load case, the error is generally small. Bstd increases the load effect from the single lane overweight vehicle load used in OPermit, in order to account for the adjacent lane of normal (legal) traffic which actually exists.

In figure 5.7.4, the 3.5kN/m² component of 0.85HO and 0.85HN loading on a transom is:

$$\text{UDL} = 0.85 \times 2(5.0/2) \times 3.5\text{kN/m}^2 = 14.875\text{kN/m} \quad \text{(along transom)}$$

The maximum load on hanger A from 0.85HO:

$$= \frac{[0.85 \times 120 \times (6.55 + 4.45)] + (14.875 \times 3.0 \times 5.5)}{7.5} = 182.3\text{kN}$$

The total mass of the 0.85HO load acting on the transom:

$$= (0.85 \times 120 \times 2) + (14.875 \times 3) = 248.6\text{kN}$$

The maximum load on hanger A from 0.85HN in the adjacent lane is 39.1kN.

Therefore, the total load (overload) on hanger A = 182.3 + 39.1 = 221.4kN

As OPermit only applies one lane of overweight load for the INFLUENCE element,

$$\text{BSTD} = 221.4/248.6 = 0.89$$

CAPAC is the overload tensile capacity of the hangar.

Example 4: Transom cantilever

The following example shows how INFLUENCE can be used to model transom cantilevers.

A typical arrangement for a bridge with a transom cantilever is shown in figure 5.7.5.

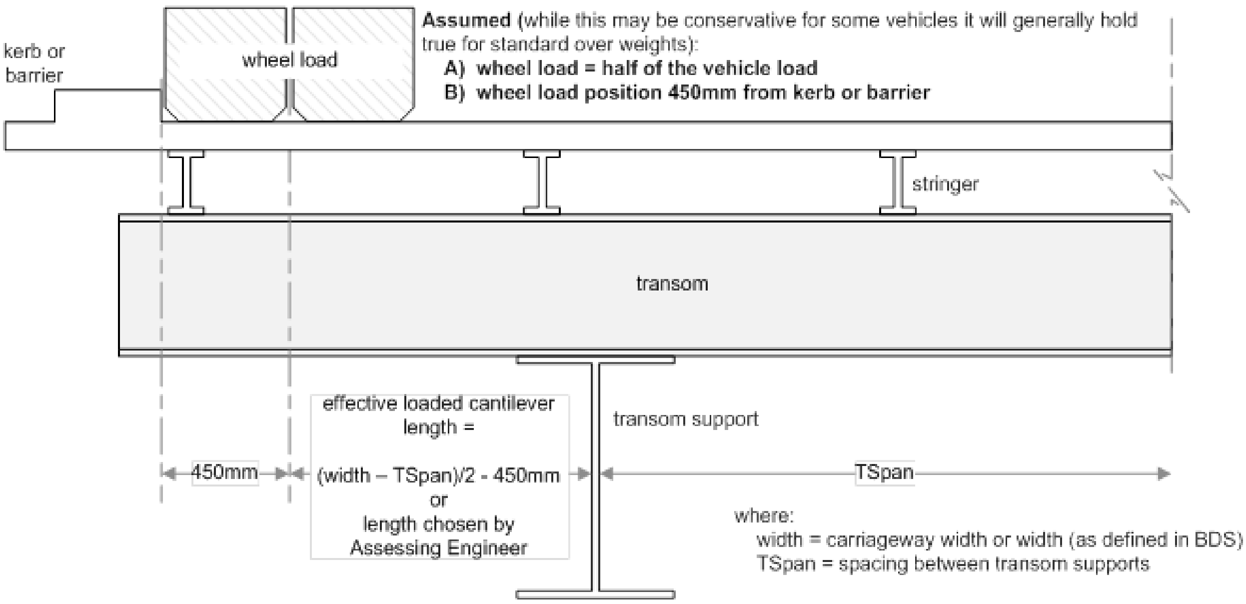



Figure 5.7.5: A typical cantilevered transom arrangement

The influence line for load on the transom is shown in figure 5.7.6. Note that only one wheel track (half the axle loading) will act on the cantilever. The peak of the influence line is therefore 0.5 instead of 1.0.

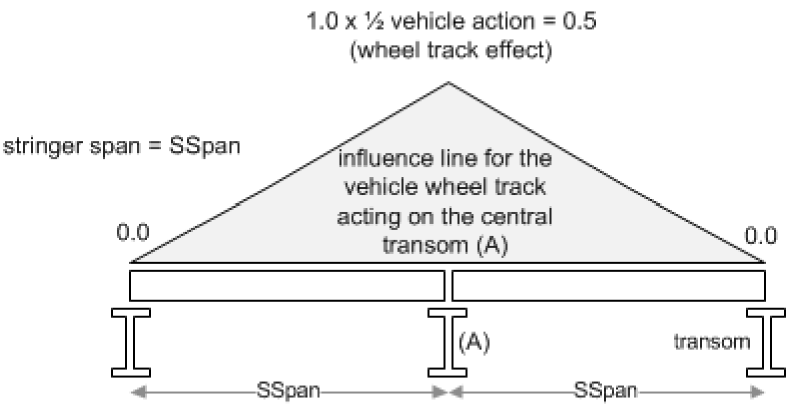



Figure 5.7.6: Half vehicle action on the cantilever

The INFLUENCE element data would include:

- Number (n) = 3
- YPositions = 0, SSpan, 2SSpan
- Influence Coefficients (s) = 0, 0.5, 0.

If shear is critical, the element could have a description of 'Transom Cantilever – Shear' and Bstd (for shear) would be 1.0.

If moment is critical, the element could have a description of 'Transom Cantilever – Moment' and Bstd (for moment) would be the effective loaded cantilever length. Bcentre would be set to zero (0) if the wheels do not load the cantilever.

CAPAC for the transom is the overload moment or shear capacity at the cantilever support (ie total capacity minus permanent load effects). If combined bending and shear is considered to be an issue, the moment capacity or the shear capacity should be reduced to account for this. An assessment of whether this is applicable can be made using the 0.85HO vehicle. As a general rule, if the moment effect is more than 75% of the beam's flexural capacity or the shear effect is more than 60% of the beam's shear capacity, consideration should be given to combined bending and shear and the CAPAC reduced accordingly.

Example 5: Cantilevered timber deck

The following example shows how INFLUENCE can be used to model timber deck cantilevers. A typical arrangement for a bridge with a deck cantilever is shown in figure 5.7.7.

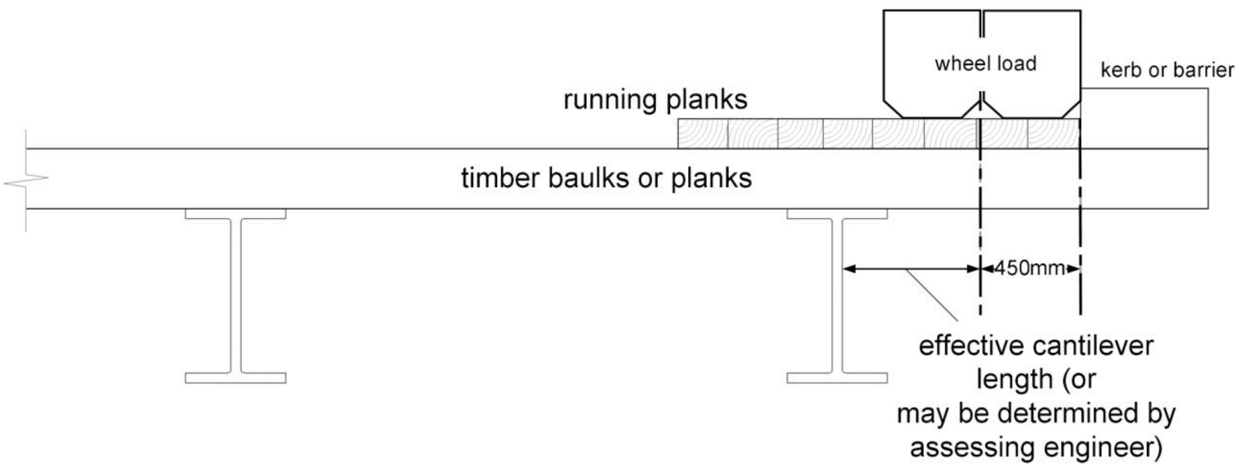



Figure 5.7.7: Typical cantilevered timber deck arrangement

The influence line for load on the deck is shown in figure 5.7.8. Note that only one wheel track (half the axle loading) will act on the cantilever. The peak of the influence line is therefore 0.5 instead of 1.0. The length of the influence line is limited to 500mm, to ensure that only one axle is considered at a time as the deck cantilever planks are only loaded at any time by one axle. In effect, this influence line determines the maximum wheel load of the particular vehicle being assessed. Note that this will be conservative for a 4-wheeled axle.

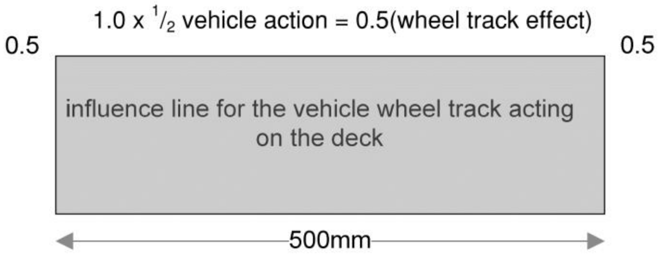



Figure 5.7.8: Half vehicle action on the timber cantilever

The INFLUENCE element data would include:

- Number (n) = 2
- YPositions = 0, 0.5
- Influence Coefficients (s) = 0.5, 0.5.

If shear is critical, the element could have a description of 'Deck Cantilever – Shear' and Bstd (for shear) = 1.0. If moment is critical, the element could have a description of 'Deck Cantilever – Moment' and Bstd (for moment) = effective cantilever length.

CAPAC = shear or moment capacity of the timber deck over the distribution width (ie the net live load capacity provided by the effective deck width perpendicular to the cantilever span – refer to section 5.3.2). Note that CAPAC needs to account for the reduced shear or moment capacity due to combined shear and moment effects.

## 5.8 CHECK element data

### 5.8.1 CHECK element overview

CHECK elements are bridge-specific messages used to augment the structural elements, explain specific requirements or alert users to specific issues. CHECK elements provide additional information to the Permit Issuing Officer (PIO), the Assessing Engineer (AE) and the driver of the overweight vehicle.

Three CHECK types are available:

- CHECK 1: general instructions/notification for PIO and/or AE. This information is not presented on the permit.
- CHECK 2: driver instructions that only apply to restriction level 3 (crawl central). This information is presented on the permit.
- CHECK 3: driver instructions for all overweight vehicles crossing the bridge. This information is presented on the permit.

In order to avoid confusion, CHECK 2 and CHECK 3 instructions do not appear on the permit for 'Do Not Cross' bridge restrictions.

### 5.8.2 CHECK element data (Form no. BSD8)

Table 5.8.1 describes the data requirements for the CHECK element.

Table 5.8.1: Input data for the CHECK element

| Form no. BSD8 input data | Specifications | Mandatory (M)/ Default (D)/ Optional (O) |
|---|---|---|
| Bridge Name | See table 5.1.1 | M |
| BSN | See table 5.1.1 | M |
| Direction | See table 5.1.4 | M |
| Check 1 | Where a CHECK 1 element is present, it is highlighted on the OPermit analysis output each time an overweight permit is processed for the bridge. This is to alert the PIO and/or the AE of specific issues or requirements relating to the evaluation of the permit application at the specific bridge.<br>This information may be technical or non-technical and is not presented on the permit (ie it is not available to the driver of the overweight vehicle).<br>A maximum of 255 characters may be used. | O (None or any CHECK element descriptions boxes may be filled in) |
| Check 2 | Where a CHECK 2 element is present, it is activated (ie presented on the permit) only when an overweight vehicle is required to travel at restriction level 3 (ie crawl central or at offset RestrictX) on the bridge.<br>Check 2 information is presented on the permit for the purpose of informing the driver of specific requirements at bridges for which restriction level 3 applies. The description must be specific and unambiguous, providing the driver with clear instruction.<br>A maximum of 255 characters may be used. | O (None or any CHECK element descriptions boxes may be filled in) |
| Check 3 | Where a CHECK 3 element is present, it is shown on all permits for any overweight vehicle crossing that particular bridge. The purpose of the Check 3 element is to notify the driver of specific requirements for all overweight vehicles crossing that bridge. The description must be specific and unambiguous, providing the driver with clear instruction.<br>A maximum of 255 characters may be used. | O (None or any CHECK element descriptions boxes may be filled in) |
| Comments | Comments may be provided to elaborate on any assumptions or relevant issues or information affecting the development of data which may be important for future reference.<br>The maximum number of characters is 255. | O |

### 5.8.3 CHECK examples

Example 1: CHECK 1 element examples

Typical examples of different types of CHECK 1 element are given below.

- PIO actions required to evaluate the overweight permit application:
  - When no data is stored, CHECK 1 elements might be ‘No structural details – Refer to bridge consultant’ or ‘No structural details – Bridge capacity is not critical on this route’
  - For an unusual (infrequent) vehicle configuration that causes specific structural concerns or is difficult to model, or which, if modelled, might unnecessarily restrict most vehicles, the CHECK 1 element might be ‘For 4 or more oscillating axles within a close-spaced axle group, refer to bridge consultant’

- A specific action for the PIO might be presented, such as for a bridge with a weak deck – eg 'If vehicle has oscillating axle (type 4 or 8), refer to bridge consultant'
- For some bridges (eg very long bridges), restriction level 3 (crawl central) might cause unacceptable traffic disruption. In such cases the PIO can be instructed to consider a less restrictive option, eg 'If restriction level 3 (crawl central) is specified, then subject to the FoC being less than 0.9, the overweight vehicle may travel at 20km/h over the bridge at specified offset or central position'.

- PIO instructions that must be addressed when evaluating the bridge:
  - For, say, a suspension bridge with a specific maximum gross mass limit based on cable capacity, the CHECK 1 element might be 'Max gross overload – Unrestricted = 45,000kg, Restricted (10km/h central) = 50,000kg'. In conjunction, the driver should be advised, with a CHECK 3 element, 'No other heavy vehicles on bridge'
  - Bridges for which overweight vehicles are unacceptable and a bypass route is available would have a CHECK 1 element such as 'No overweight vehicles allowed on bridge – use SH74'
  - For a bridge with a very narrow deck, the CHECK 1 element might be 'Confirm overall axle width does not exceed 2.9m'.
- PIO advice for particular bridges:
  - For example at interchanges, the CHECK 1 element might be 'Bridge carries northbound off-ramp traffic only'
  - If a specific load configuration is encountered, such as for weak, close-spaced transoms, the CHECK 1 element could be 'If vehicle has oscillating axle, the max axle mass is as follows: Restriction level –1 = 11,000kg, RL 0 = 12,000kg, RL 1 = 12,600kg, RL 2 = 13,200kg, RL 3 = 13500kg'.

### Example 2: CHECK 2 element examples

Typical examples of CHECK 2 elements are as follows.

- To provide instruction on vehicle positioning:
  - 'For travel towards Christchurch, position vehicle centreline 4.5 metres from left side barrier. For travel towards Ashburton, position vehicle centreline 2.5 metres from left side barrier'
  - 'For travel towards Wellington, position vehicle in opposing lane'
  - To position vehicle off a half bridge, the CHECK 2 element might be 'Position vehicle as close as possible to uphill bank'.
- To provide advice to the driver:
  - For traffic management when travelling in opposing lane, the CHECK 2 element could be 'When travelling in opposing lane, traffic will need to be stopped 100m north of bridge'.

### Example 3: CHECK 3 element examples

Typical examples of CHECK 3 elements are as follows.

- To provide instruction on vehicle positioning:
  - To avoid loading areas of the bridge, such as weak deck cantilevers, the CHECK 3 element might be 'Vehicle must be at least 1m clear of barrier'
  - To limit loading on the bridge, the instruction might be 'There shall be no other heavy vehicles on the passing bay while overweight vehicle crosses bridge'.

- To provide instruction on vehicle speed:
  - To reduce impact/vibration effects, speed may be restricted, eg ‘Maximum speed 30 km/h’.
- To provide advice to the driver:
  - Advice might be given on available clearance, eg ‘Bridge barriers are 800mm high and 3.2m apart. Confirm load clearance’
  - Advice might be given on the available width of a narrow bridge, eg ‘Confirm that overall axle width does not exceed the 2.9m available between kerbs’.

# 6 REFERENCES

Where further guidance is required it is recommended that the following documents be consulted:


- *Bridge overweight rating and posting weight assessment* (SP/M/018) – June 2002
- *Bridge manual*, 3rd edition (SP/M/022) – May 2013
- *Vehicle dimension and mass permitting manual*, volume 1, part B: Overweight permits – July 2015
- Hambly, E.C. *Bridge deck behaviour*, 2nd edition. Oxon: CRC Press/Taylor & Francis, 1991

# 7 APPENDICES

Appendix A - Data input forms

Appendix B - Structural data examples

Appendix C - Standard data

Appendix D - OPermit outputs

# Appendix A – Data input forms

# GENERAL ELEMENT DATA (FORM No. BSD1)

Note: This form must be completed for all structures.

This sheet is accompanied by ............ Element Data sheets.

Location data

| | |
|---|---|
| Bridge Name | |
| Road Identification | |
| Route Position | |
| Bridge Structure Number (BSN) | |
| Region | |
| Road Controlling Auth. or NZTA Region | |

Bypass data

| | |
|---|---|
| Bypass Type | |
| Bypass Description | |

Posting data

| | | |
|---|---|---|
| Posting | | % |

Structural data

| | | |
|---|---|---|
| Direction | | |
| Width | | m |
| RestrictX (Increasing) | | m |
| RestrictX (Decreasing) | | m |
| Comments | | |

Prepared: ......................................................................... DATE: .......... / .......... / ........

Checked:........................................................................... DATE: .......... / .......... / ........

Certified for release: ............................................................. DATE: .......... / ........... / .........

**Bridge Inspection Engineer** ......................................................

# DECKSLAB ELEMENT DATA (FORM No. BSD2)

| | |
|---|---|
| Bridge Name | |
| BSN | |
| Direction | |

DECKSLAB element no. ......... of .........

| | |
|---|---|
| Type | DECKSLAB |
| Description | |
| Impact Code | 2 |
| DCF | |
| Comments | |

Prepared: ........................................................................ DATE: .......... / .......... / ........

Checked:.......................................................................... DATE: .......... / .......... / .........

# TIMBDECK ELEMENT DATA (FORM No. BSD3)

| | |
|---|---|
| Bridge Name | |
| BSN | |
| Direction | |

TIMBDECK element no. ……… of ………

| | | | | |
|---|---|---|---|---|
| Type | TIMBDECK | | | |
| Description | | | | |
| Impact Code | 1 | | If Number > 0 | |
| Type Code | | | Position | |
| DCF | | | | m |
| Span | | m | | |
| MCAP | | kNm/m | | |
| SCAP | | kN/m | | |
| Plank | | m | | |
| Dist Code | | | | |
| Number | | | | |
| Comments | | | | |

Prepared: ……………………………………………………………………… DATE: ………. / ………. / ……..

Checked:……………………………………………………………………… DATE: ………. / ………. / ……..

# BEAM ELEMENT DATA (FORM No. BSD4)

| | |
|---|---|
| Bridge Name | |
| BSN | |
| Direction | |

BEAM element no. ……… of ………

| | | |
|---|---|---|
| Type | BEAM | |
| Description | | |
| Impact Code | | |
| Estd | | |
| Ecentre | | |
| Estd(12) | | |
| Estd(16) | | |
| Ecentre(12) | | |
| Ecentre(16) | | |
| Span | | m |
| MCAP | | kNm |
| SCAP | | kN |
| Comments | | |

Prepared: ……………………………………………………………………… DATE: ………. / ………. / ………

Checked:……………………………………………………………………… DATE: ………. / ………. / ………

# VBEAM ELEMENT DATA (FORM No. BSD5)

| | |
|---|---|
| Bridge Name | |
| BSN | |
| Direction | |

VBEAM element no. ......... of .........

| | | |
|---|---|---|
| Type | VBEAM | |
| Description | | |
| Impact Code | | |
| Span | | m |
| NBeams | | |
| NDisc | | |

| MCAP | | SCAP | | XPosition | |
|---|---|---|---|---|---|
| | kNm | | kN | | m |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Position of Discontinuities:

| | | | | |
|---|---|---|---|---|
| | | | | m |

| | |
|---|---|
| Comments | |

Prepared: ........................................................................... DATE: .......... / .......... / ........

Checked:............................................................................ DATE: .......... / .......... / .........

# TRANSOM ELEMENT DATA (FORM No. BSD6)

| | |
|---|---|
| Bridge Name | |
| BSN | |
| Direction | |

TRANSOM element no. ......... of .........

| | | |
|---|---|---|
| Type | TRANSOM | |
| Description | | |
| Impact Code | | |
| TSpan | | m |
| SSpan | | m |
| MCAP | | kNm |
| SCAP | | kN |
| Comments | | |

Prepared: ....................................................................... DATE: .......... / .......... / .........

Checked:......................................................................... DATE: .......... / .......... / .........

# INFLUENCE ELEMENT DATA (FORM No. BSD7)

| | |
|---|---|
| Bridge Name | |
| BSN | |
| Direction | |

INFLUENCE element no. ......... of .........

| | | | | | |
|---|---|---|---|---|---|
| Type | INFLUENCE | | | | |
| Description | | | | | |
| Impact Code | | | | | |
| Stress Number | | | | | |
| Bstd | | Bstd(12) | | Bstd(16) | |
| Bcentre | | Bcentre(12) | | Bcentre(16) | |
| YLength | | m | | | |
| CAPAC | | kNm or kN | | | |
| Number | | | | | |

| YPosition | | Influence Coefficient | |
|---|---|---|---|
| | m | | kNm/kN or kN/kN |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

| | |
|---|---|
| Comments | |

Prepared: ......................................................................... DATE: .......... / .......... / ........

Checked:.......................................................................... DATE: .......... / .......... / .........

# CHECK ELEMENT DATA (FORM No. BSD8)

| | |
|---|---|
| Bridge Name | |
| BSN | |
| Direction | |

| TYPE | CHECK |
|---|---|
| CHECK 1<br>[PIO/Approv. Engineer notification only. Not printed on permit] | |
| CHECK 2<br>[Driver instruction. Printed on permit ONLY when restriction level 3 (crawl central) occurs] | |
| CHECK 3<br>[Printed on all permits] | |

| | |
|---|---|
| Comments | |

Prepared: ........................................................................... DATE: .......... / .......... / .........

Checked:............................................................................. DATE: .......... / .......... / .........

# Appendix B – Structural data examples

Structural data examples will be posted on the Transport Agency website as they become available. Please check the webpage of this guide, which may be accessed via www.nzta.govt.nz/resources.

# Appendix C – Standard data

Examples of standard data will be posted on the Transport Agency website as they become available. Please check the webpage of this guide, which may be accessed via www.nzta.govt.nz/resources.

# Appendix D – OPermit output reports

This appendix includes example OPermit output reports to which annotations have been added for additional explanation.

The following example reports are included in this Appendix:

- Summary Report
- Element Comparison Report
- Detailed Report, with examples for the following elements:
  - BEAM
  - VBEAM
  - DECKSLAB
  - TIMBDECK
  - TRANSOM
  - INFLUENCE
- Pavement Loading Report.

**SUMMARY Report Example**

# Summary Report

Date/Time: 26 Nov 2012 10:58:30 AM

Permit application number : 99999

Schema Version: 1

## Vehicle Information

Owner: Opermit test co

Units:

| Unit Type | Registration |
|---|---|
| Tractor | 4.8.18 Tractor |
| Trailer | 4.8.18 trailer |

Max Speed: 90

Vehicle Type: Large project transporter

VAI: 1.35

VGI: 2.210

Gross Mass: 90.80

Number Of Axles: 8

Load Width: 2.50

Load Length:

Load Height: 6.00

*Overweight vehicle dimensions and axle weights*

| Axle No: | Axle Spacing (m): | Axle Load (t): | Axle Type: | Track Width: | Tyre Size: | Axle Index: |
|---|---|---|---|---|---|---|
| 1 | 0.000 | 5.40 | S | 2.000 | Standard | 1.04 |
| 2 | 2.000 | 5.40 | S | 2.000 | Standard | 1.04 |
| 3 | 3.500 | 10.00 | T | 1.800 | Standard | 1.35 |
| 4 | 1.400 | 10.00 | T | 1.800 | Standard | 1.35 |
| 5 | 6.000 | 15.00 | 8 | 2.600 | Standard | 1.27 |
| 6 | 2.400 | 15.00 | 8 | 2.600 | Standard | 1.27 |
| 7 | 2.400 | 15.00 | 8 | 2.600 | Standard | 1.27 |
| 8 | 2.400 | 15.00 | 8 | 2.600 | Standard | 1.27 |

## Route Data

| Section: | Highway: | From RP: | From Junction: | To RP: | To Junction: |
|---|---|---|---|---|---|
| 1.0 | SH1N | 44/0.0 | 10 | 1081/0.0 | 15 |

*Overweight vehicle route definition*

**SUMMARY Report Example**

*Overweight Vehicle max travel speed*

Restricted and Unrestricted Bridges

| ID: | Highway: | RP: | BSN: | Bridge Name: | Analysis Direction: | Speed Limit: | Position: | Risk: |
|---|---|---|---|---|---|---|---|---|
| 31484 | 1N | 44/9.69 | 536 | REIDS BRIDGE No. 184 (TE AWHIA STREAM) (BOTH) | increasing | 50 | Own Lane | |
| 31486 | 1N | 44/17.23 | 611 | KIMBERLY CREEK BRIDGE NO 187 (BOTH) | increasing | 90 | Own Lane | |
| 31487 | 1N | 44/17.32 | 612 | WAIHOPO LANDING BRIDGE NO 188 (BOTH) | increasing | 90 | Own Lane | |
| 31489 | 1N | 65/1.68 | 666 | WATERFALLS BRIDGE NO 190 (BOTH) | increasing | 90 | Own Lane | |
| 31491 | 1N | 65/4.25 | 692 | LAMBS BRIDGE NO 192 (BOTH) | increasing | 90 | Own Lane | |
| 36253 | 1N | 477/6.14 | 4831 | MERCER RAIL OVERPASS (INCREASING) | increasing | | No elements for direction | |
| 31492 | 1N | 65/7.33 | 723 | RAIO BRIDGE NO 193 (BOTH) | increasing | 50 | Own Lane | |
| 31495 | 1N | 65/15.01 | 800 | YERKOVICHS BRIDGE NO 194 (BOTH) | increasing | 90 | Own Lane | |
| 31497 | 1N | 83/15.51 | 994 | WAIPAPAKAURI BRIDGE NO 203 (BOTH) | increasing | 90 | Own Lane | |
| 31498 | 1N | 83/15.79 | 997 | WAIPAPAKAURI BRIDGE NO 204 (BOTH) | increasing | 90 | Own Lane | |
| 31499 | 1N | 83/19.48 | 1033 | AWANUI RIVER BRIDGE NO 78 (BOTH) | increasing | 10 | Central | |
| 31500 | 1N | 104/6.30 | 1103 | WAIKURUKI BRIDGE NO 77 (BOTH) | increasing | 90 | Own Lane | |
| 31501 | 1N | 104/14.52 | 1185 | DOUBLE CROSSING BRIDGE NO 74 (BOTH) | increasing | 10 | Central | |
| 31502 | 1N | 119/3.94 | 1229 | MILL BRIDGE No. 73 (BOTH) | increasing | 10 | Own Lane | |
| 31505 | 1N | 119/10.21 | 1292 | TRACEYS BRIDGE NO 2043 (BOTH) | increasing | 10 | Central | |
| 31581 | 1N | 273/16.76 | 2898 | TAUROA STREAM BRIDGE NO 98 (BOTH) | increasing | 10 | 3.70 | |
| 31640 | 1N | 414/6.86 | 4211 | TANK FARM LAGOON BRIDGE (INCREASING) | increasing | | Bridge data invalid | |
| 31506 | 1N | 119/10.55 | 1296 | TRACEYS BRIDGE NO 2042 (BOTH) | increasing | 10 | Central | |
| 31507 | 1N | 119/11.30 | 1303 | THOMPSONS BRIDGE NO 2041 (BOTH) | increasing | 10 | Central | |
| 31508 | 1N | 119/11.70 | 1307 | RAMSEYS BRIDGE No. 69 (BOTH) | increasing | 50 | Own Lane | |
| 31510 | 1N | 134/5.13 | 1391 | GRAYSONS BRIDGE NO 67 (BOTH) | increasing | 20 | Own Lane | |
| 31511 | 1N | 134/6.98 | 1410 | MANGAMUKA RIVER BRIDGE NO 66 (BOTH) | increasing | 20 | Own Lane | |
| 31512 | 1N | 134/7.20 | 1412 | GOOSE CAMP BRIDGE NO 65 (BOTH) | increasing | 50 | Own Lane | |
| 31513 | 1N | 134/9.27 | 1433 | BUSBYS BRIDGE NO 64 (BOTH) | increasing | 10 | Own Lane | |
| 31514 | 1N | 149/0.26 | 1493 | MANGAMUKA RIVER BRIDGE No. 58 (BOTH) | increasing | 10 | Own Lane | |
| 31516 | 1N | 149/6.37 | 1554 | MCDONALDS BRIDGE No. 54 (BOTH) | increasing | 20 | Own Lane | |
| 31518 | 1N | 149/13.01 | 1620 | HUATAU STREAM BRIDGE NO 51 (BOTH) | increasing | 10 | Central | |
| 31519 | 1N | 149/14.79 | 1638 | WAIHOU RIVER (RANGIAHUA) BRIDGE No. 50 (BOTH) | increasing | 10 | Central | |
| 31522 | 1N | 167/1.97 | 1690 | ROBINSONS BRIDGE NO 49 (BOTH) | increasing | 10 | Central | |
| 31524 | 1N | 167/8.40 | 1754 | WAIOTEMANU BRIDGE NO 43 (BOTH) | increasing | 0 | DNC | |
| 31527 | 1N | 190/4.31 | 1943 | WAIARUHE STREAM BRIDGE No 40 (BOTH) | increasing | 10 | Central | |

*Overweight vehicle to travel in own lane*

*Overweight vehicle to travel at 3.7m from left hand kerb*

*Overweight vehicle to travel central on carriageway*

*DNC = Do Not Cross. Overweight not permitted on bridge*

**Element Comparison Report Example**

## Element Comparison Report

Date/Time: 26 Nov 2012 11:05:06 AM

Permit application number : 99999

Schema Version: 1

### Vehicle Information

Owner: Opermit test co

Units:

| Unit Type | Registration |
|---|---|
| Tractor | 4.8.18 Tractor |
| Trailer | 4.8.18 trailer |

Max Speed: 90

Vehicle Type: Large project transporter

VAI: 1.35

VGI: 2.210

Gross Mass: 90.80

Number Of Axles: 8

Load Width: 2.50

Load Length:

Load Height: 6.00

*Overweight vehicle dimensions and axle weights*

| Axle No: | Axle Spacing (m): | Axle Load (t): | Axle Type: | Track Width: | Tyre Size: | Axle Index: |
|---|---|---|---|---|---|---|
| 1 | 0.000 | 5.40 | S | 2.000 | Standard | 1.04 |
| 2 | 2.000 | 5.40 | S | 2.000 | Standard | 1.04 |
| 3 | 3.500 | 10.00 | T | 1.800 | Standard | 1.35 |
| 4 | 1.400 | 10.00 | T | 1.800 | Standard | 1.35 |
| 5 | 6.000 | 15.00 | 8 | 2.600 | Standard | 1.27 |
| 6 | 2.400 | 15.00 | 8 | 2.600 | Standard | 1.27 |
| 7 | 2.400 | 15.00 | 8 | 2.600 | Standard | 1.27 |
| 8 | 2.400 | 15.00 | 8 | 2.600 | Standard | 1.27 |

### Route Data

| Section: | Highway: | From RP: | From Junction: | To RP: | To Junction: |
|---|---|---|---|---|---|
| 1.0 | SH1N | 0/0.0 | 10 | 1081/0.0 | 15 |

*Overweight vehicle route definition*

## Element Comparison Report Example

*Element Restriction Levels*
*NME=no element*
*ND = no data*

*BEAM*
*Element FOC's*
*only (may not be*
*critical)*

*Bridge Restriction based on*
*critical element*

*Overweight*
*vehicle speed*
*restriction for*
*bridge*

| Highway | RP | BSN | Bridge Name | Analysis Direction | BEAM | VBEAM | DECK SLAB | TIMB DECK | TRANSOM | INFLUENCE LINE | | Fraction of Capacity | | | Critical Restriction | Speed Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Moment | Shear | Code | Description | |
| 1N | 461/0.19 | 4622 | DRURY RAIL OVERBRIDGE SOUTHBOUND | increasing | -1 | NME | NME | NME | NME | NME | | 0.68 | 0.00 | -1 | Unrestricted | 90 |
| 1N | 461/8.56 | 4697 | ST STEPHENS OVERBRIDGE (SOUTHBOUND) | increasing | -1 | NME | NME | NME | NME | NME | | 0.90 | 0.00 | -1 | Unrestricted | 90 |
| 1N | 461/10.71 | 4709 | CULVERT C (BOMBAY) | increasing | -1 | NME | NME | NME | NME | NME | | 0.97 | 0.00 | -1 | Unrestricted | 90 |
| 1N | 461/11.79 | 4738 | WHITES CULVERT | increasing | -1 | NME | NME | NME | NME | NME | | 0.97 | 0.00 | -1 | Unrestricted | 90 |
| 1N | 477/0.63 | 4779 | TWIN BRIDGES SOUTH BOUND | increasing | 0 | NME | NME | NME | NME | NME | | 0.98 | 0.00 | 0 | 50 km/h Own Lane | 50 |
| 1N | 477/1.74 | 4789 | SOUTH BOUND ON RAMP UNDERPASS | increasing | 0 | NME | NME | NME | NME | NME | | 0.89 | 0.00 | 0 | 50 km/h Own Lane | 50 |
| 1N | 477/2.10 | 4801 | POKENO RAIL OVERBRIDGE (SOUTHBOUND) | increasing | -1 | NME | NME | NME | NME | NME | | 0.74 | 0.00 | -1 | Unrestricted | 90 |
| 1N | 477/2.10 | 4801 | POKENO RAIL OVERBRIDGE (NORTHBOUND) | increasing | -1 | NME | 1 | NME | NME | NME | | 0.79 | 0.00 | 1 | 20 km/h Own Lane | 20 |
| 1N | 477/3.45 | 4805 | PIONEER ROAD UNDERPASS | increasing | NME | NME | -1 | NME | NME | NME | | | | -1 | Unrestricted | 90 |
| 1N | 477/4.01 | 4810 | MANGATAWHIRI RIVER BRIDGE (SOUTHBOUND) | increasing | -1 | NME | -1 | NME | NME | NME | | 0.95 | 0.00 | -1 | Unrestricted | 90 |
| 1N | 477/6.14 | 4831 | MERCER RAIL OVERPASS | increasing | ND | ND | ND | ND | N | ND | | | | | *Refer to bridge consultant* | |
| 1N | 477/6.65 | 4837 | TE PUEA BRIDGE | increasing | 2 | NME | NME | NME | NME | NME | | 0.89 | 0.89 | 2 | Crawl Own Lane | 10 |
| 1N | 477/7.82 | 4848 | TEOTEO BRIDGE | increasing | 1 | NME | NME | NME | NME | NME | | 0.97 | 1.00 | 1 | 20 km/h Own Lane | 20 |
| 1N | 502/10.76 | 5141 | KIMIHIA STREAM BRIDGE | increasing | -1 | NME | NME | NME | NME | NME | | 0.97 | 0.00 | -1 | Unrestricted | 90 |
| 1N | 519/6.94 | 5259 | MANGAWARA STREAM BRIDGE | increasing | 1 | NME | -1 | NME | NME | NME | | 0.99 | 0.00 | 1 | 20 km/h Own Lane | 20 |
| | | **CHECK 2: VEHICLE CENTRELINE TO BE LOCATED 4.65 M FROM UPSTREAM KERB FACE** | | | | | | | | | | | | | | |
| 1N | 519/10.00 | 5290 | HOPUHOPU RAIL OVERBRIDGE | increasing | 2 | NME | 2 | NME | NME | NME | | 0.95 | 0.00 | 2 | Crawl Own Lane | 10 |
| | | **CHECK 2: VEHICLE CENTRELINE TO BE LOCATED 4.9 M FROM LEFT HAND KERB FACE** | | | | | | | | | | | | | | |
| 1N | 533/0.00 | 5330 | WAIKATO RIVER BRIDGE (NGARUAWAHIA) | increasing | 3 | NME | 1 | NME | -1 | NME | | | | | *Refer to bridge consultant* | |
| | | **CHECK 2: VEHICLE CENTRELINE TO BE LOCATED 2.82 M FROM FOOTWAY KERB** | | | | | | | | | | | | | | |
| *CHECK Message relates to bridge on line above* | | | HOROTIU INTERCHANGE BRIDGE | increasing | -1 | NME | -1 | NME | NME | NME | | 0.61 | 0.74 | -1 | Unrestricted | 90 |
| | | | TE RAPA DAIRY FACTORY VEHICLE UNDERPASS | increasing | -1 | NME | NME | NME | NME | NME | | 0.83 | 0.77 | -1 | Unrestricted | 90 |
| 1N | 543/3.40 | 5464 | AVALON DRIVE RAIL OVERBRIDGE | increasing | 0 | NME | 1 | NME | NME | NME | | 0.91 | 0.00 | 1 | 20 km/h Own Lane | 20 |
| 1N | 543/7.17 | 5502 | FOREST LAKE RD OVERBRIDGE | increasing | -1 | NME | NME | NME | NME | NME | | 0.84 | 0.35 | -1 | Unrestricted | 90 |
| 1N | 554/0.59 | 5536 | COBHAM BRIDGE (WAIKATO RIVER) | increasing | -1 | NME | 1 | NME | NME | NME | | 0.42 | 0.23 | 1 | 20 km/h Own Lane | 20 |
| 1N | 554/3.13 | 5561 | HILLCREST PEDESTRIAN UNDERPASS | increasing | 1 | NME | NME | NME | NME | NME | | 0.42 | 0.99 | 1 | 20 km/h Own Lane | 20 |
| 1N | 557/3.46 | 5604 | TAMAHERE OVERBRIDGE | increasing | -1 | NME | NME | NME | NME | NME | | 0.98 | 0.00 | -1 | Unrestricted | 90 |
| 1N | 568/6.98 | 5750 | KARAPIRO STREAM BRIDGE | increasing | -1 | NME | 1 | NME | -1 | -1 | | | | | *Refer to bridge consultant* | |
| 1N | 594/3.64 | 5982 | WAITOA STREAM BRIDGE | increasing | 0 | NME | NME | NME | NME | NME | | 0.92 | 0.00 | 0 | 50 km/h Own Lane | 50 |
| 1N | 605/1.26 | 6063 | ORAKA STREAM BRIDGE (NORTH) | increasing | 3 | NME | 2 | NME | NME | NME | | 0.75 | 0.00 | 3 | Crawl Central | 10 |

**Detailed Report Example**
**BEAM element**

| Highway | Reference Stn | Displacement | Bridge Name | Direction |
|---|---|---|---|---|
| 1N | 300 | 9.99 | OPERMIT BRIDGE | 1 - Increasing |

Width of Carriageway: 16.30
Number of Lanes Loaded: 2
Restrict X: *No value = central on beams*

Speed Limit:
Legal Loading Limit: 0 *Posting (%). "0" means not posted i.e. >100%*
Bypass Description:

**Element Analysis**
Element Type: Beam
Element Name: LONG BOX GIRDER SPANS 2 & 3

Element Direction: BOTH ( Relevant to Both Directions )

*Moment Capacity* *Shear Capacity*

| Impact Code | ESTD | E_CENTR | SPAN | MCAP | SCAP |
|---|---|---|---|---|---|
| 3 | 1.800 | 1.800 | 32.004 | 51,547 | 0 |

*"0" value = shear not critical*

| | | | |
|---|---|---|---|
| KBASIC: | 1.550 | | |
| Basic Vehicle Moment: | 4829.27 | Mpost: | 3,423.87 |
| Basic Vehicle Shear: | 676.10 | Spost: | 480.75 |

*Legal vehicle (0.85HN) effect on span, incl impact.*

*Overweight vehicle effect on span (no impact factor)*

*e – refer to Data guide section 5.4.4*

Element Analysis Direction: INCREASING

*Refer data guide Clause 4.8*

*Total action on span including overweight load, adjacent lane load, eccentricity, and impact*

| Restriction Level | Impact Factors | | Eccent | Total | | Fraction of Capacity | |
|---|---|---|---|---|---|---|---|
| | Moment | Shear | Factor | Moment | Shear | Moment | Shear |
| Unrestricted | 1.34 | 1.43 | 1.867 | 18,433 | 2,702 | 0.36 | 0.00 |
| 50 km/h Own Lane | 1.21 | 1.30 | 1.835 | 17,045 | 2,495 | 0.33 | 0.00 |
| 20 km/h Own Lane | 1.14 | 1.20 | 1.814 | 16,224 | 2,344 | 0.31 | 0.00 |
| Crawl Own Lane | 1.00 | 1.00 | 1.765 | 14,565 | 2,042 | 0.28 | 0.00 |
| Crawl Central | 1.00 | 1.00 | 1.800 | 8,693 | 1,217 | 0.17 | 0.00 |

Element Messages:
**Element Result:** **Increasing: -1 - Unrestricted** *Restriction Level calculated for this element*

$\frac{\text{Total Moment}}{\text{MCAP}} = FoC$

$\frac{\text{Total Shear}}{\text{SCAP}} = FoC$ *(in this case SCAP = 0 as shear not critical & therefore not checked by OPermit)*

**Detailed Report Example**
**VBEAM element**

Element Type: VBeam
Element Name: Span 6 beams 3& 4
Element Direction: DECREASING ( Relevant to Decreasing Travel)
Impact Code: 3
SPAN: 25.400

*Transverse position of beam relative to left hand kerb (m)*

*Beam Moment Capacity, MCAP (kNm)*

*Beam Shear Capacity, SCAP (kN)*

**Beam Inputs**

| Beam Number | X_Position | M_Capacity | S_Capacity | |
|---|---|---|---|---|
| 1 | 4.180 | 4,190 | 723 | |
| 2 | 6.030 | 3,422 | 683 | |

*Transverse position of discontinuity from LH kerb*

**Discontinuity Inputs**

| Discontinuity No | X_Position |
|---|---|
| 1 | 3.200 |

*Critical transverse position of overweight vehicle from LH kerb*

*Moment effect of the overweight vehicle on the **span** (excl impact)*

*The number of the axle at the critical longitudinal position*

*Critical Longitudinal position of the overweight vehicle*

*Moment effect of adjacent legal vehicle (0.85HN +I) on **span** (kNm)*

*FoC = (Total moment* on Critical beam) / MCAP*

**this is calculated for the critical beam using the distribution rules in the Data Guide section 5.5.3, for the overweight at the X_position & Y_section shown on the report*

Element Analysis Direction: DECREASING

| Restriction Level | Impact Factor | Vehicle C.L. X_Position | Beam No. *Critical beam* | Beam Moment | Axle on Y_Section | Critical Y_Section | Posting Moment | Fraction of Capacity |
|---|---|---|---|---|---|---|---|---|
| Unrestricted | 1.43 | 2.879 | 1 | 3,405.89 | 6 | 13.800 | 0.00 | 1.88 |
| 50km/h Own Lane | 1.24 | 2.879 | 1 | 3,405.89 | 6 | 13.800 | 0.00 | 1.71 |
| 20km/h Own Lane | 1.16 | 2.879 | 1 | 3,405.89 | 6 | 13.800 | 0.00 | 1.60 |
| Crawl Own Lane | 1.00 | 2.879 | 1 | 3,405.89 | 6 | 13.800 | 0.00 | 0.38 |
| Crawl Central | 1.00 | 4.000 | 1 | 3,405.89 | 6 | 13.800 | 0.00 | 0.92 |

*0.00 in the example means no adjacent legal vehicle, eg. single lane bridge or wide overweight*

**Critical Shear:** **true** ← *VBeam element has SCAP values, and shear check results are reported below. Headings have similar meanings to the moment results table above*

| Restriction Level | Impact Factor | Vehicle C.L. X_Position | Beam No. | Beam Shear | Axle on Y_Section | Critical Y_Section | Posting Shear | Fraction of Capacity |
|---|---|---|---|---|---|---|---|---|
| Unrestricted | 1.43 | 2.879 | 1 | 620.29 | 8 | 25.400 | 0.00 | 2.09 |
| 50km/h Own Lane | 1.30 | 2.879 | 1 | 620.29 | 8 | 25.400 | 0.00 | 1.90 |
| 20km/h Own Lane | 1.20 | 2.879 | 1 | 620.29 | 8 | 25.400 | 0.00 | 1.75 |
| Crawl Own Lane | 1.00 | 2.879 | 1 | 620.29 | 8 | 25.400 | 0.00 | 1.46 |
| Crawl Central | 1.00 | 4.000 | 1 | 620.29 | 8 | 25.400 | 0.00 | 0.97 |

Element Messages:
**Element Result:** **Decreasing: 3 – Crawl Central** ← *Restriction Level calculated for this element*

**Detailed Report Example**
**DECKSLAB element**

Element Type: Deck-Slab
Element Name: DECK SLAB ALL SPANS
Element Direction: BOTH ( Relevant to Decreasing Travel )

| | |
|---|---|
| **VAI:** 1.33 | *Vehicle Axle Index (refer to Overweight Permit Manual)* |
| DCF: 1.00 | *Deck Capacity Factor (refer to Bridge Manual)* |

Impact Code: 2 *2 = Impact code for concrete deck slabs*
Length: 8.94 *Length of slab (value may or may not be present as historical value not used by OPermit)*

*Speed related parameters to calculate impact factor (DLF) for overweight vehicles*

| Restriction Level | Kv | Ks | Impact Factors | DLR |
|---|---|---|---|---|
| Unrestricted | 1.10 | 3.00 | 1.43 | 1.760 |
| 50 km/h Own Lane | 1.00 | 3.00 | 1.30 | 1.600 |
| 20 km/h Own Lane | 1.00 | 2.00 | 1.20 | 1.477 |
| Crawl Own Lane | 1.00 | 0.00 | 1.00 | 1.231 |
| Crawl Central | 1.00 | 0.00 | | |

*Deck Loading Ratio – refer Data Guide Section 5.2.1*
*If DLR ≤1.30 vehicle may pass at that Restriction Level.*

Element Messages:
**Element Result:** **Increasing: 2 - Crawl Own Lane, Decreasing: 2 - Crawl Own Lane** *Restriction Level calculated for this element.*

**Detailed Report Example**
**TIMBDECK element**

Element Type: Timber Deck
Element Name: TIMBER DECKS

Element Direction: BOTH ( Relevant to Increasing Travel )

*Moment and Shear capacity of timber deck / (unit width), kNm/m or kN/m*

| Impact Code | Type Code | Dist Code | Span (m) | MCAP | SCAP | Plank(m) Width | Number of Xpositions |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 3 | 1.219 | 66 | 0 | 0.204 | 1 |

*1=spanning transversely*
*2=Spanning longitudinally*

*Code to determine timber deck distribution width – see data guide table 5.3.1.*

*Span of timber deck element.*

*Width of timber element.*

*For Type 1 only, number of positions the deck element occurs across the bridge carriageway. See Data Guide table 5.3.2.*

**Element Positions**

| X_Position (m) |
|---|
| 0.000 |

*Left hand x-position of the element (if specified). See Data Guide table 5.3.2.*

Element Analysis Direction: INCREASING

**Basic Moment Results:**

| Basic Vehicle Moment/ Strip (kNm/m) | Xposition (m) | Under Axle No | Vehicle Centreline Xposition (m) |
|---|---|---|---|
| 11.728 | 0.650 | 3 | 1.579 |

*Overweight vehicle wheel moment on timber element (kNm)*

**Basic Shear Results:**

| Basic Vehicle Shear/ Strip (kN/m) | Xposition (m) | Under Axle No | Vehicle Centreline Xposition (m) |
|---|---|---|---|
| 32.958 | 0.000 | 5 | 1.579 |

| Deck Loading Ratio (DLR) |
|---|
| 0.750 |

*If DLR < 1.30, passes simple check and OPermit does not carry out a detailed check*

**Maximum Distribution Strip Widths:**

| | | | |
|---|---|---|---|
| Moment: | 0.314 | Shear: | 0.314 |

*Distribution widths (m) used by OPermit*

*Overweight vehicle moment on deck planks per metre width (kNm/m)*
*Overweight vehicle shear on deck planks per metre width (kN/m)*

**Restriction Level Results:**

| Restriction | Impact Factors | | Per Metre | | Fraction of Capacity | |
|---|---|---|---|---|---|---|
| | Moment | Shear | Moment | Shear | Moment | Shear |
| Unrestricted | **1.00** | **1.00** | **37.29** | **104.80** | **0.56** | **0.00** |
| Crawl Central | 0.00 | 0.00 | 0.00 | 0.00 | | |

*In this example, for central travel vehicle not in contact with the element, so values are '0"*

Element Messages: INCREASING Results Message: Vehicle passes simple checks. *(Note: in this example the detailed check report has been included as well as the simple check, as OPermit was processed as a 'feasibility' permit)*

**Element Result:** **Increasing: -1 - Unrestricted**

**Detailed Report Example**
**TRANSOM element**

Element Type: Transom
Element Name: TRANSOMS SPANS 1 2 & 3.

Element Direction: BOTH (Relevant to Both Directions)

*Span of Transom (m) longitudinal*
*Span of stringer (m) or deck*
*Transom moment capacity (kNm)*
*Transom shear capacity (kNm), if "0" not critical and OPermit does not check*

| Impact Code | TSPAN | SSPAN | MCAP | SCAP |
|---|---|---|---|---|
| 2 | 4.877 | 4.648 | 320 | 684 |

Element Analysis Direction: BOTH

*Calculated maximum vehicle load to the transom based on a moving load along the bridge.*

| Under Axle | Basic vehicle reaction at transom |
|---|---|
| 2 | 146.795 |

*Critical axle no. for moment & shear effect*
*Refer data guide CIause 4.8*
*Total action on transom including overweight load, adjacent lane load, and impact factors.*

**Critical Axles**

| Restriction Level | Critical axle | | Impact Factor | | Total | | Fraction of Capacity | |
|---|---|---|---|---|---|---|---|---|
| | Moment | Shear | Moment | Shear | Moment (kNm) | Shear (kN) | Moment (kNm) | Shear (kN) |
| Unrestricted | 2 | 2 | 1.43 | 1.43 | 208 | 194 | 0.65 | 0.28 |
| 50 km/h Own Lane | 2 | 2 | 1.30 | 1.30 | 199 | 179 | 0.62 | 0.26 |
| 20 km/h Own Lane | 2 | 2 | 1.20 | 1.20 | 195 | 171 | 0.61 | 0.25 |
| Crawl Own Lane | 2 | 2 | 1.00 | 1.00 | 187 | 166 | 0.58 | 0.24 |
| Crawl Central | 2 | 2 | 1.00 | 1.00 | 109 | 99 | 0.34 | 0.15 |

$$\frac{\underline{Total\ Moment}}{MCAP} = FoC$$

**Element Result:** **Increasing: -1 – Unrestricted** **Decreasing: -1 - Unrestricted**

**Detailed Report Example**
**INFLUENCE element**

Element Type: Influence Line
Element Name: TRANSVERSE CANTILEVER BEAMS – ALL SPANS

Element Direction: INCREASING ( Relevant to Increasing Travel )

*1=moment or torsion in (kNm)*
*2=Shear or axial (in kN)*

| | | | |
|---|---|---|---|
| Stress Number: | 1 | BCENTR: | 1.00 |
| Impact Code: | 2 | SPAN (YLength = x): | 7.000 |
| BSTD: | 1.00 | CAPACITY: | 121.00 |

*Scale factor for 'central' travel by overweight at Restriction Level 3 (Crawl Central)*
*Span of influence element*
*Capacity for overload vehicle kN or kNm. Must be positive value*

*Scale factor for own lane travel by overweight vehicle*

**INFLUENCE LINE Ordinate Information**

| Y_Position | Coefficient |
|---|---|
| 0.000 | 0.000 |
| 1.520 | 0.200 |
| 3.050 | 0.390 |
| 4.570 | 0.200 |
| 6.100 | 0.000 |

*Coordinates to describe the influence line refer to Data Guide section 5.7.*

*Maximum value due to overweight vehicle – See Data Guide section 5.7*

Element Analysis Direction: INCREASING

| | | | |
|---|---|---|---|
| Unfactored +ve Stress: | 81.56 | Front Axle at Y: | 18.40 |

*Critical position of overweight vehicle along influence element*

| Restriction Level | Impact Factor | Scale Factor | Factored Load | Fraction of Capacity |
|---|---|---|---|---|
| Unrestricted | 1.43 | 1.10 | 11,291.85 | 0.36 |
| 50 km/h Own Lane | 1.30 | 1.10 | 10,265.32 | 0.33 |
| 20 km/h Own Lane | 1.20 | 1.10 | 9,475.68 | 0.30 |
| Crawl Own Lane | 1.00 | 1.10 | 7,896.40 | 0.25 |
| Crawl Central | 1.00 | 1.00 | 7,178.54 | 0.23 |

$\frac{\textit{Factored Load}}{\textit{CAPACITY}} = \textit{FoC}$

*Bstd or Bcentre value*

*Unfactored +ve stress × Impact Factor × Scale Factor*

Element Messages:

**Element Result:** **Increasing: -1 - Unrestricted**

*Restriction Level calculated for this element*

**PAVEMENT LOADING Report Example**

## Pavement Loading Report

Date/Time: 12 Aug 2013 9:40:23 AM Permit application number : 99999 Schema Version: 1

### Vehicle Information

Owner: Opermit test co

Units:

| Unit Type | Registration |
|---|---|
| Tractor | Test |

Max Speed: 50
Vehicle Type: Agricultural Vehicle
VAI: 1.60
VGI: 1.140
Gross Mass: 24.00
Number Of Axles: 2
Load Width: 2.00
Load Length:
Load Height: 2.00

*Overweight Vehicle axle and tyre information.*

| Axle No: | Axle Spacing (m): | Axle Load (t): | Axle Type: | Track Width: | Tyre Size: | Axle Index: |
|---|---|---|---|---|---|---|
| 1 | 0.000 | 12.00 | S | 2.000 | 710/75R34 | 1.41 |
| 2 | 3.500 | 12.00 | S | 2.000 | 600/65R28 | 1.60 |

### Route Information

(1) Highway SH1N from RP 477/0.0 (Junc 20) to RP 794/0.0

**Pavement Restrictions**

| Grade | Pavement Loading Ratio | From RP | To RP | Distance (km) |
|---|---|---|---|---|
| A | 160.00 | 0/0.0 | 1081/0.47 | 1,081.47 |

*Route information and calculated Pavement Loading Ratio.*

(2) Highway SH1B from RP 0/0.0 (Junc 1B0) to RP 46/0.0 (Junc 1B9)

**Pavement Restrictions**

| Grade | Pavement Loading Ratio | From RP | To RP | Distance (km) |
|---|---|---|---|---|

(3) Highway SH1C from RP 0/0.0 (Junc 1N- 1C0) to RP 0/6.3 (Junc 1N- 1C9)

**Pavement Restrictions**

| Grade | Pavement Loading Ratio | From RP | To RP | Distance (km) |
|---|---|---|---|---|
| A | 160.00 | 0/0.0 | 0/6.3 | 6.30 |

(4) Highway 1N- ETA from RP 0/0.0 (Junc 1N- ETA1) to RP 0/16.0 (Junc 1N- ETA9)

**Pavement Restrictions**

| Grade | Pavement Loading Ratio | From RP | To RP | Distance (km) |
|---|---|---|---|---|
| A | 160.00 | 0/0.0 | 0/16.0 | 16.00 |

4 pavements checked.

### Pavement Messages:

Cannot issue permit. Single Trip Permits may be available.
The PLR exceeds 150%. Permit Officer must obtain approval and special conditions from Approving Engineer for local roads, and Network Operations Group National Office for state highways.

*Output message and overall pavement restriction*

Permit Application Number: 99999. Page 1 of 1