

Archie-M Standard Loads

SV Loads from BD86 and CS458

1 Document History

- 2025-06-18 HH
 - BUG FIX: SV Trailer load in previous version used wheel loads (half axle load) on full axle width.
 - Change narrative to refer to Available Width instead of bridge width.
 - Added this change log to ldf file header.
- 2023-06-14 HH
 - Update for CS458.
 - Add SV196 bogies (4 and 5 165kN axles).
 - Different interpretation of lift-off rules (previous version applied lift-off to first and last axles of bogie regardless of number of axles; now we apply in three axle groups).
 - Orientation of SV196 (formerly SVTrain) and SVTT Tractor models switched for consistency.
 - Versions without symmetrical loads (for Archie-M 2.6) and with (for 2.5.1) generated.
- 2021-04-22 HH/WJH
 - Fixed SV150 loads to include overhang term, 2017 version will have used 1.8m for axle width.
- 2017-10 WJH First version distributed, not included in app installer

2 Introduction

CS458 (and previously BD86) define a set of “SV load models” to be used in assessing for STGO vehicle movements. The models are intended to capture key properties of the full range of STGO vehicles.

In this document, we examine the vehicles and rules regarding load factors, and develop an Archie-M load file.

SV vehicles are mostly relatively simple, but the rules for application are much more complex. CS458 introduced some changes over BD86 that required consideration.

Users of these load definitions should read both CS458 and this document carefully. CS458 is complex and not always clear. We have interpreted the rules as written, but it is your responsibility to ensure that the loads used in assessment *both* satisfy the standard *and* reasonably represent the real situation of concern.

If you think there is an error in the loads, or you disagree with the interpretation of the standards given here, please email us at support@obvis.com.

3 Handling asymmetry

Both loads and bridges may be asymmetrical. If either load or bridge is symmetrical, it is only necessary to run a load in one orientation. If *both* bridge and load are asymmetrical, it is necessary to check the load in both orientations, as either direction may be critical.

Up to version 2.5.1 of Archie-M, autorun did not check loads in both orientations, and complete assessment required two versions of each asymmetrical load to be included in the load file.

The lift-off rules of CS458 appear to require lift-off to be applied to each group of three axles in a bogie. With SV196 bogies including up to 6 axles, load cases proliferate (there are 8 lift-off cases including symmetrical cases). The load list becomes unwieldy, and where a bridge is symmetrical, many of these loads add nothing to the assessment.

As of Archie-M 2.6, autorun will check for asymmetry in the load, and will run loads in both directions if asymmetrical. These load files therefore *do not* contain symmetrical pairs of loads.

We do not currently test for bridge symmetry. Robust checks for symmetry would be quite complex, and an entirely symmetrical bridge (with perfectly flat road) is the exception rather than the rule.

Note: a separate file is generated for use with Archie-M 2.5.1 which should include all symmetrical load cases.

4 Vehicle and available (formerly “bridge”) widths

The distribution model used by Archie-M is that from BD21/CS454, which is naive in the extreme, and makes it impossible to deal sensibly with complex bridges or loads.

If there is room on the bridge for two notional lanes and the load can fit entirely within one, the code requires that an HA load is applied in the next lane. BD21 says that HA loads are not appropriate for arches so the interpretation of this is difficult, but essentially it means limit the SV vehicle to its own space. The “Available Width” input in Archie-M should be set to the appropriate width to be occupied by this load alone, which might be the whole bridge. In any case, the available width must not be set to less than the vehicle width, which appears as the last item in the load definition.

However, there is a further complication. The track of the axles in general SV vehicles is 2.65m, which means that, under the BD21/CS454 distribution rules, the influence of two wheels will not overlap until the depth of fill at the load position is 1.15m. For most bridges, the critical axle is likely to be a smaller distance above the ring so it is necessary to analyse for wheels, rather than axles, and to use an appropriate Available Width (Figure 4.1).

The exception to this is the SVTT Trailer, which has 4 wheels equally spaced across each axle. This close spacing of wheel loads means that distributions from wheels will merge even with little cover, so axle loads must be used. A different bridge will be needed for the wheel loads of the SVTT Tractor, and the axle loads of the SVTT trailer. Assessing for SVTT loads may therefore require two bridge models.

The Archie-M load files separate the axle loads of SVTT Trailer and the wheel loads for all other SV bogies under separate load families (top level sections) so they can be selected independently in assessment.

A bug in the load files supplied with Archie-M 2.6 resulted in SVTT Trailer loads being halved as if they were wheel loads.

4 Vehicle and available (formerly “bridge”) widths

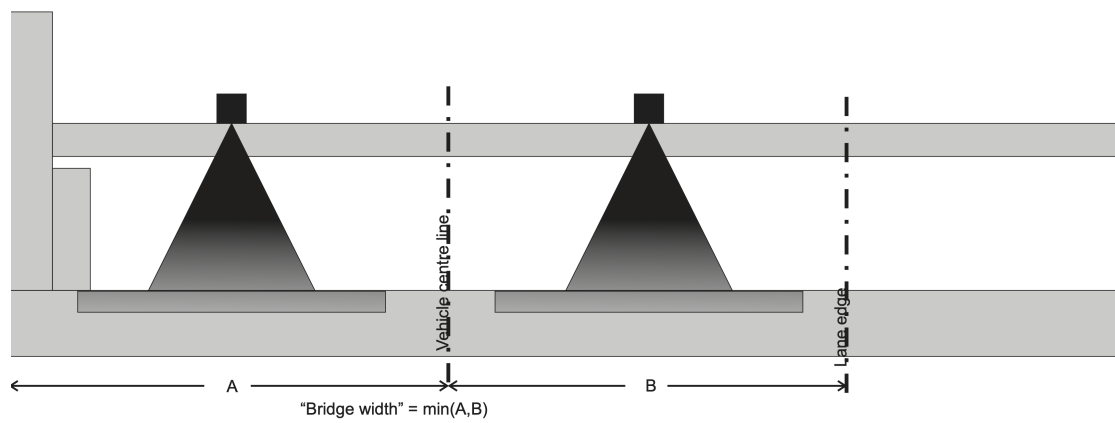


Figure 4.1: “Bridge” width for distribution

5 Factors of safety

Clause 3.44 of BD86/07 indicates that that γ_{fL} (for alternative methods to MEXE) shall be 2.0 for SV loading and “associated HA loading or AW vehicles”.

The reference to associated loading specifically for masonry structures in BD86 is odd. The effective strip model of transverse distribution means assessment can typically only consider single wheels of the SV load.

It is more than a little surprising that, despite the reasons given in BD21 for using a factor of 2 overall, BD86 Cl 3.35 insists that the factor of 2 is in combination to the axle factors discussed below.

No clause similar to BD86/07 Cl.3.44 is found in CS458 (but MEXE is explicitly disallowed for SV loading, CS458 Clause 3.64).

The absence of a specified γ_{fL} in CS458 suggests that the normal CS454 value is to be used. Note that CS454 reduced this factor from the 1.9 used in BD21 to 1.8. The change was the result of rounding differences because the way the factor is derived was changed, but produces an apparent 5% increase in capacity under standard loads. Use of this 1.8 factor from CS454 in place of 2.0 from BD86 represents a 10% increase in assessed capacity under SV loads.

Please review these clauses and consider the implications carefully.

6 Load Factors

6.1 Overload factor (CS458 Rev0 Cl.3.33; BD86/07 Cl.3.24)

The overload factor is to be 1.2 for worst critical axle, 1.1 for others. This is most simply implemented by applying a factor of 1.1 to all axles, and one of 1.2/1.1 to the critical axle.

Independent certification criteria allow reduction of the Overload Factor either to 0.95OF, or to 1.0, depending on the type of certification. This creates a proliferation of load cases.

6.2 Dynamic amplification factor (DAF) (CS458 Rev0 Cl.3.34, BD86/07 Cl.3.25)

CS454 uses an “impact factor”, usually 1.8, which is applied to the critical axle only (Clause 5.9). BD86 and CS458 have a Dynamic Amplification Factor (DAF), applied to all axles, which is a function of the unfactored axle weight. It is never over 1.35, and tends to 1.05 as unfactored axle weight increases.

DAF is defined as:

$$DAF(q_{ka}) = \left[1.7 \left(\frac{q_{ka}}{10} \right)^{-0.15} \right] \geq 1.05$$

where q_{ka} is the *unfactored* axle load.

DAF is applied to all axles. There does not appear to be a single axle impact.

It is implied in this clause, but not stated explicitly, that DAF not applied where vehicles are travelling at low speed (below 10mph).

The plot of DAF in CS458 does not match the formula. It is striking that the line drops below 1.05. Overplotting to compare (see Figure 6.1) show other deviations. We use the formula.

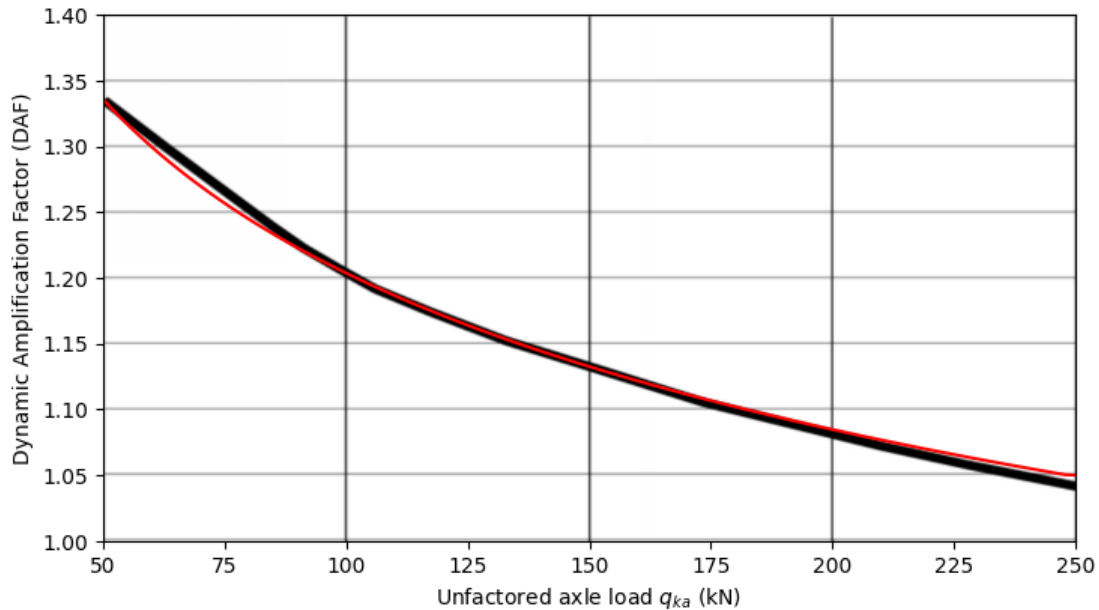


Figure 6.1: DAF from formula overlaid on plot from CS458.

6.3 Lift-off (CS458 Rev0 Cl.3.65; BD86/07 Cl.3.42)

The issue of liftoff is an interesting one. Modern vehicles are so well articulated that lift-off is very rare. The geometry of the process is illustrated in Figure 6.2. The minimum requirements are a long stiff body, a long bogie and a relatively steep rise and fall such that the other end of the vehicle is on a noticeably different vertical alignment from the bogie. Figure 6.2 shows the most common form, though it can also happen if there is a long steep rise and fall from a crest so that the tractor in this layout is heading down one slope while the trailer is still rising on the other side.

This sketch should also clarify what is meant by a bogie: a set of axles with shared suspension, that under normal circumstances would carry equal load.

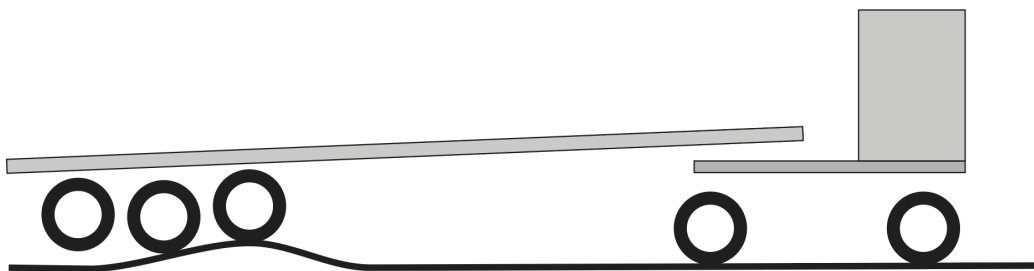


Figure 6.2: The geometry of lift-off

6 Load Factors

The previous Archie-M load files for SV loads applied lift-off factors to the leading and trailing axles in bogies with three or more axles. Re-reading this clause in both standards indicates that this may not have been as intended.

The meaning of the clause *has* changed between BD86 in CS458.

- CS458: Lift-off rules should be applied to the *group of three axles within the bogies that causes the worst effect*.
- BD86: Lift-off rules should be applied to the *axle with the worst effect and the two following axles*.

No rationale is given for the change, or for either approach. The CS458 formulation seems to allow situations in which the most critical axle load would be unchanged or even reduced by lift-off.

Lift-off as a result of road geometry would have different and more complex results than those allowed by either standard. If lift-off causes an increase in critical axle load, there is no obvious reason why the axle lifting off must be two axles behind the critical axle.

Lift-off is not to be applied for the low speed case. This seems odd; lift off surely isn't a dynamic effect. Dynamic effects are already handled by the Dynamic Amplification Factor.

The approach taken is to generate a load case with lift-off applied to each group of three axles. These are labelled "Lift-off on 1" etc where axle 1 has an increased load from lift-off. "Lift-off on 1" in the load case name implies a reduced load on axle 3.

Because bogies, not vehicle, are critical for most masonry bridges, and bogies have equal axle weight and spacing before application of axle factors, we can generate a set the critical axle at the front of a set of three. The opposite configuration will be generated by reversing the road. Load reversing in autorun is implemented from Archie-M 2.6 (February 2023) on.

No guidance is given on lift-off in the SV196 and SVTT tractors, which both have a pair of heavy axles. We have applied lift-off across the axle pair, as CS454 would, but using CS458 factors (1.2/0.8 rather than the CS454 1.5/0.5).

6.4 Combining factors

The order of application of factors is not clearly specified. Lift-off is required only for masonry arches, and is introduced last in CS458, but applying it last would mean that the 1.2 factor on the critical axle was applied after enhancing for overload, and lift-off would then change the total load. This is not how lift-off is expected to behave, so we have chosen to apply lift-off before critical axle overload. The full order is:

1. Dynamic Amplification Factor DAF is calculated from the unfactored axle load.
2. Overload Factor OF for all axles is applied.

3. DAF is applied equally to all axles.
4. Lift-off is applied while axle loads within bogie are equal, otherwise total load will change.
5. Critical axle increment of OF is applied.

6.5 Low speed

For speeds not greater than 10mph:

1. Lift-off can be omitted (CS458 R0 Cl.3.66; BD86/07 Cl.3.42)
2. DAF can *probably* be omitted, see below.

6.5.1 Lift-off

Dropping lift-off at low speed is odd. The behaviour lift-off represents is the inability of a bogie, as part of a vehicle, to accommodate road shape. It is a geometrical issue, not a dynamic one, unless the idea is that suspension systems in STGO type vehicles can accommodate arbitrary road shape, but with some latency, such that if the vehicle is moving over 10mph the suspension may not be able to adapt quickly enough.

That lift-off is indeed a geometrical issue is supported by the fact that it is only mentioned in CS458 in the context of masonry bridges.

We have followed the standard, and provided low speed loads without lift-off. This is probably not the biggest issue with the handling of lift-off in these vehicles.

6.5.2 DAF

Removing the dynamic amplification factor makes much more sense. CS458 Clause 3.34 states that DAF is to be applied for normal speed. It is implied rather than stated that it need to be applied for low speed.

BD86/07 says nothing about DAF being speed dependent in the main clause. In Appendix B, the last sentence of section 4 reads “Where the speed of the STGO vehicle is restricted to less than 10 mph, the DAF factor is reduced to 1.0.” Appenix B is supposed to be about the basis for the main clauses, but this appears to be an additional hidden clause.

6.6 Certification of loads

CS458 allows for reduction of the Overload Factor if either the total load, or axle loads and spacings are independently certified. Certification of the total load allows an overload factor of $0.95 \times$ the full factor to be used. Certification of axle loads and spacings offers the possibility of reducing the overload factors to 1.0 (including, presumably, that on the critical axle).

Certification of axle loads and spacings will presumably be for a real vehicle, not a SV load model?

7 Vehicles

7.1 SV load models

SV load model vehicles consist of some combination of

- Groups of axles at 1.2m spacing (which we will refer to as “bogies”)
- Tractors

Multiple groups of axles/tractors may be combined into a vehicle, with large and variable gaps between them.

Single bogies or tractors will be critical for all but the largest span arches.

7.2 SV80

Here we have 2 groups of three axles with 2.4m spread in the groups. Under current guidance, even for viaducts, this will only be critical if the whole length fits in half the span, so 6m overall or 12m span. Indeed a trial with Archie will probably show that the smallest span for a 6m spread to be critical is rather more than 12m. We therefore need to consider a single bogie for most cases.

The dynamic factor for a 130kN axle is 1.157, so the axle loads for Archie are 15.35tonnes. The overload factor is either 1.1 or 1.2 yielding loads of 16.89tonnes or 18.42tonnes. With the further application of lift-off, factors of 1.2 and 0.8 are applied to axles 1 and 3. Giving 22.1tonnes for the critical axle (which must surely be the one which already has a 1.2 factor) and 13.51tonnes for the trailing axles.

To deal with loads on single wheels, it is necessary to take into account the calculation that Archie does, which is illustrated in figure Figure 4.1. For highway wheel loads we must set the axle length to zero.

The loads for this model are therefore:

7 Vehicles

```
%FAMILY: SV Bogies as single wheels, Normal speed (> 10mph)

%GROUP: SV80 bogie No lift-off - Note: Needs 1.5m min AND to suit edge distances

SV80 bogie Axle 1 critical, 26.09, 3, 1, 9.21, 1.200, 8.44, 1.200, 8.44, 1, 0.000; 1.500
SV80 bogie Axle 2 critical, 26.09, 3, 1, 8.44, 1.200, 9.21, 1.200, 8.44, 1, 0.000; 1.500

%GROUP: SV80 bogie Lift-off - Note: Needs 1.5m min AND to suit edge distances

SV80 bogie Axle 1 critical, 26.25, 3, 1, 11.05, 1.200, 8.44, 1.200, 6.75, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Low speed (<= 10mph)

%GROUP: SV80 bogie Low speed - Note: Needs 1.5m min AND to suit edge distances

SV80 bogie Axle 1 critical, 22.55, 3, 1, 7.96, 1.200, 7.30, 1.200, 7.30, 1, 0.000; 1.500
SV80 bogie Axle 2 critical, 22.55, 3, 1, 7.30, 1.200, 7.96, 1.200, 7.30, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified loads, Low speed (<= 10mph)

%GROUP: SV80 bogie Low speed - Note: Needs 1.5m min AND to suit edge distances

SV80 bogie Axle 1 critical, 21.42, 3, 1, 7.56, 1.200, 6.93, 1.200, 6.93, 1, 0.000; 1.500
SV80 bogie Axle 2 critical, 21.42, 3, 1, 6.93, 1.200, 7.56, 1.200, 6.93, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified axles, Low speed (<= 10mph)

%GROUP: SV80 bogie Low speed - Note: Needs 1.5m min AND to suit edge distances

SV80 bogie Axle 1 critical, 19.90, 3, 1, 6.63, 1.200, 6.63, 1.200, 6.63, 1, 0.000; 1.500
SV80 bogie Axle 2 critical, 19.90, 3, 1, 6.63, 1.200, 6.63, 1.200, 6.63, 1, 0.000; 1.500
```

7.3 SV100

SV100 bogies have 3 no. 165kN axles at 1.2m spacing.

7 Vehicles

```
%FAMILY: SV Bogies as single wheels, Normal speed (> 10mph)

%GROUP: SV100 bogie No lift-off - Note: Needs 1.5m min AND to suit edge distances

SV100 bogie Axle 1 critical, 31.95, 3, 1, 11.28, 1.200, 10.34, 1.200, 10.34, 1, 0.000; 1.500
SV100 bogie Axle 2 critical, 31.95, 3, 1, 10.34, 1.200, 11.28, 1.200, 10.34, 1, 0.000; 1.500

%GROUP: SV100 bogie Lift-off - Note: Needs 1.5m min AND to suit edge distances

SV100 bogie Axle 1 critical, 32.14, 3, 1, 13.53, 1.200, 10.34, 1.200, 8.27, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Low speed (<= 10mph)

%GROUP: SV100 bogie Low speed - Note: Needs 1.5m min AND to suit edge distances

SV100 bogie Axle 1 critical, 28.62, 3, 1, 10.10, 1.200, 9.26, 1.200, 9.26, 1, 0.000; 1.500
SV100 bogie Axle 2 critical, 28.62, 3, 1, 9.26, 1.200, 10.10, 1.200, 9.26, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified loads, Low speed (<= 10mph)

%GROUP: SV100 bogie Low speed - Note: Needs 1.5m min AND to suit edge distances

SV100 bogie Axle 1 critical, 27.19, 3, 1, 9.60, 1.200, 8.80, 1.200, 8.80, 1, 0.000; 1.500
SV100 bogie Axle 2 critical, 27.19, 3, 1, 8.80, 1.200, 9.60, 1.200, 8.80, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified axles, Low speed (<= 10mph)

%GROUP: SV100 bogie Low speed - Note: Needs 1.5m min AND to suit edge distances

SV100 bogie Axle 1 critical, 25.26, 3, 1, 8.42, 1.200, 8.42, 1.200, 8.42, 1, 0.000; 1.500
SV100 bogie Axle 2 critical, 25.26, 3, 1, 8.42, 1.200, 8.42, 1.200, 8.42, 1, 0.000; 1.500
```

7.4 SV150

SV150 bogies have 5 no. 146kN bogies at 1.2m spacing. This wider spread of lower axle loads is unlikely to be critical.

7 Vehicles

```
%FAMILY: SV Bogies as single wheels, Normal speed (> 10mph)

%GROUP: SV150 bogie No lift-off - Note: Needs 1.5m min AND to suit edge distances

SV150 bogie Axle 1 critical, 47.43, 5, 1, 10.16, 1.200, 9.32, 1.200, 9.32, 1.200, 9.32,
  ⇨ 1.200, 9.32, 1, 0.000; 1.500
SV150 bogie Axle 2 critical, 47.43, 5, 1, 9.32, 1.200, 10.16, 1.200, 9.32, 1.200, 9.32,
  ⇨ 1.200, 9.32, 1, 0.000; 1.500
SV150 bogie Axle 3 critical, 47.43, 5, 1, 9.32, 1.200, 9.32, 1.200, 10.16, 1.200, 9.32,
  ⇨ 1.200, 9.32, 1, 0.000; 1.500

%GROUP: SV150 bogie Lift-off - Note: Needs 1.5m min AND to suit edge distances

SV150 bogie Axle 1 critical, 47.60, 5, 1, 12.20, 1.200, 9.32, 1.200, 7.45, 1.200, 9.32,
  ⇨ 1.200, 9.32, 1, 0.000; 1.500
SV150 bogie Axle 2 critical, 47.60, 5, 1, 9.32, 1.200, 12.20, 1.200, 9.32, 1.200, 7.45,
  ⇨ 1.200, 9.32, 1, 0.000; 1.500
SV150 bogie Axle 3 critical, 47.60, 5, 1, 9.32, 1.200, 9.32, 1.200, 12.20, 1.200, 9.32,
  ⇨ 1.200, 7.45, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Low speed (<= 10mph)

%GROUP: SV150 bogie Low speed - Note: Needs 1.5m min AND to suit edge distances

SV150 bogie Axle 1 critical, 41.71, 5, 1, 8.94, 1.200, 8.19, 1.200, 8.19, 1.200, 8.19,
  ⇨ 1.200, 8.19, 1, 0.000; 1.500
SV150 bogie Axle 2 critical, 41.71, 5, 1, 8.19, 1.200, 8.94, 1.200, 8.19, 1.200, 8.19,
  ⇨ 1.200, 8.19, 1, 0.000; 1.500
SV150 bogie Axle 3 critical, 41.71, 5, 1, 8.19, 1.200, 8.19, 1.200, 8.94, 1.200, 8.19,
  ⇨ 1.200, 8.19, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified loads, Low speed (<= 10mph)

%GROUP: SV150 bogie Low speed - Note: Needs 1.5m min AND to suit edge distances

SV150 bogie Axle 1 critical, 39.63, 5, 1, 8.49, 1.200, 7.78, 1.200, 7.78, 1.200, 7.78,
  ⇨ 1.200, 7.78, 1, 0.000; 1.500
SV150 bogie Axle 2 critical, 39.63, 5, 1, 7.78, 1.200, 8.49, 1.200, 7.78, 1.200, 7.78,
  ⇨ 1.200, 7.78, 1, 0.000; 1.500
```

7 Vehicles

```
SV150 bogie Axle 3 critical, 39.63, 5, 1, 7.78, 1.200, 7.78, 1.200, 8.49, 1.200, 7.78,  
↪ 1.200, 7.78, 1, 0.000; 1.500
```

```
%FAMILY: SV Bogies as single wheels, Certified axles, Low speed (<= 10mph)
```

```
%GROUP: SV150 bogie Low speed - Note: Needs 1.5m min AND to suit edge distances
```

```
SV150 bogie Axle 1 critical, 37.24, 5, 1, 7.45, 1.200, 7.45, 1.200, 7.45, 1.200, 7.45,  
↪ 1.200, 7.45, 1, 0.000; 1.500
```

```
SV150 bogie Axle 2 critical, 37.24, 5, 1, 7.45, 1.200, 7.45, 1.200, 7.45, 1.200, 7.45,  
↪ 1.200, 7.45, 1, 0.000; 1.500
```

```
SV150 bogie Axle 3 critical, 37.24, 5, 1, 7.45, 1.200, 7.45, 1.200, 7.45, 1.200, 7.45,  
↪ 1.200, 7.45, 1, 0.000; 1.500
```

7.5 SVTrain (BD86 only)

The SVTrain load consisted of a tractor, identical to that of the new SV196 load in CS458, and two bogies which match the SV196 5 axle bogie in geometry, but have only 146kN axles. These cannot be critical where SV196 is to be considered, and are unlikely to be critical even where it isn't. The load is included for completeness.

```
%FAMILY: SV Bogies as single wheels, Normal speed (> 10mph)
```

```
%GROUP: BD86 SVTrain bogie No lift-off - Note: Needs 1.5m min AND to suit edge distances
```

```
BD86 SVTrain bogie Axle 1 critical, 47.43, 5, 1, 10.16, 1.200, 9.32, 1.200, 9.32, 1.200,  
↪ 9.32, 1.200, 9.32, 1, 0.000; 1.500
```

```
BD86 SVTrain bogie Axle 2 critical, 47.43, 5, 1, 9.32, 1.200, 10.16, 1.200, 9.32, 1.200,  
↪ 9.32, 1.200, 9.32, 1, 0.000; 1.500
```

```
BD86 SVTrain bogie Axle 3 critical, 47.43, 5, 1, 9.32, 1.200, 9.32, 1.200, 10.16, 1.200,  
↪ 9.32, 1.200, 9.32, 1, 0.000; 1.500
```

```
%GROUP: BD86 SVTrain bogie Lift-off - Note: Needs 1.5m min AND to suit edge distances
```

```
BD86 SVTrain bogie Axle 1 critical, 47.60, 5, 1, 12.20, 1.200, 9.32, 1.200, 7.45, 1.200,  
↪ 9.32, 1.200, 9.32, 1, 0.000; 1.500
```

```
BD86 SVTrain bogie Axle 2 critical, 47.60, 5, 1, 9.32, 1.200, 12.20, 1.200, 9.32, 1.200,  
↪ 7.45, 1.200, 9.32, 1, 0.000; 1.500
```

7 Vehicles

```
BD86 SVTrain bogie Axle 3 critical, 47.60, 5, 1, 9.32, 1.200, 9.32, 1.200, 12.20, 1.200,  
  ↪ 9.32, 1.200, 7.45, 1, 0.000; 1.500
```

```
%FAMILY: SV Bogies as single wheels, Low speed (<= 10mph)
```

```
%GROUP: BD86 SVTrain bogie Low speed - Note: Needs 1.5m min AND to suit edge distances
```

```
BD86 SVTrain bogie Axle 1 critical, 41.71, 5, 1, 8.94, 1.200, 8.19, 1.200, 8.19, 1.200,  
  ↪ 8.19, 1.200, 8.19, 1, 0.000; 1.500
```

```
BD86 SVTrain bogie Axle 2 critical, 41.71, 5, 1, 8.19, 1.200, 8.94, 1.200, 8.19, 1.200,  
  ↪ 8.19, 1.200, 8.19, 1, 0.000; 1.500
```

```
BD86 SVTrain bogie Axle 3 critical, 41.71, 5, 1, 8.19, 1.200, 8.19, 1.200, 8.94, 1.200,  
  ↪ 8.19, 1.200, 8.19, 1, 0.000; 1.500
```

```
%FAMILY: SV Bogies as single wheels, Certified loads, Low speed (<= 10mph)
```

```
%GROUP: BD86 SVTrain bogie Low speed - Note: Needs 1.5m min AND to suit edge distances
```

```
BD86 SVTrain bogie Axle 1 critical, 39.63, 5, 1, 8.49, 1.200, 7.78, 1.200, 7.78, 1.200,  
  ↪ 7.78, 1.200, 7.78, 1, 0.000; 1.500
```

```
BD86 SVTrain bogie Axle 2 critical, 39.63, 5, 1, 7.78, 1.200, 8.49, 1.200, 7.78, 1.200,  
  ↪ 7.78, 1.200, 7.78, 1, 0.000; 1.500
```

```
BD86 SVTrain bogie Axle 3 critical, 39.63, 5, 1, 7.78, 1.200, 7.78, 1.200, 8.49, 1.200,  
  ↪ 7.78, 1.200, 7.78, 1, 0.000; 1.500
```

```
%FAMILY: SV Bogies as single wheels, Certified axles, Low speed (<= 10mph)
```

```
%GROUP: BD86 SVTrain bogie Low speed - Note: Needs 1.5m min AND to suit edge distances
```

```
BD86 SVTrain bogie Axle 1 critical, 37.24, 5, 1, 7.45, 1.200, 7.45, 1.200, 7.45, 1.200,  
  ↪ 7.45, 1.200, 7.45, 1, 0.000; 1.500
```

```
BD86 SVTrain bogie Axle 2 critical, 37.24, 5, 1, 7.45, 1.200, 7.45, 1.200, 7.45, 1.200,  
  ↪ 7.45, 1.200, 7.45, 1, 0.000; 1.500
```

```
BD86 SVTrain bogie Axle 3 critical, 37.24, 5, 1, 7.45, 1.200, 7.45, 1.200, 7.45, 1.200,  
  ↪ 7.45, 1.200, 7.45, 1, 0.000; 1.500
```

7.6 SV196 (CS454 only)

The SV196 model has two bogies and a tractor. The two bogies are different, one has 4 axles, the other 5. All bogie axles are 165kN axles. Each bogie is modelled as these combinations do not appear elsewhere.

7.6.1 Bogie 1 (4 axles)

```
%FAMILY: SV Bogies as single wheels, Normal speed (> 10mph)

%GROUP: SV196 bogie 1 No lift-off - Note: Needs 1.5m min AND to suit edge distances

SV196 bogie 1 Axle 1 critical, 42.29, 4, 1, 11.28, 1.200, 10.34, 1.200, 10.34, 1.200,
↪ 10.34, 1, 0.000; 1.500
SV196 bogie 1 Axle 2 critical, 42.29, 4, 1, 10.34, 1.200, 11.28, 1.200, 10.34, 1.200,
↪ 10.34, 1, 0.000; 1.500

%GROUP: SV196 bogie 1 Lift-off - Note: Needs 1.5m min AND to suit edge distances

SV196 bogie 1 Axle 1 critical, 42.48, 4, 1, 13.53, 1.200, 10.34, 1.200, 8.27, 1.200, 10.34,
↪ 1, 0.000; 1.500
SV196 bogie 1 Axle 2 critical, 42.48, 4, 1, 10.34, 1.200, 13.53, 1.200, 10.34, 1.200, 8.27,
↪ 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Low speed (<= 10mph)

%GROUP: SV196 bogie 1 Low speed - Note: Needs 1.5m min AND to suit edge distances

SV196 bogie 1 Axle 1 critical, 37.88, 4, 1, 10.10, 1.200, 9.26, 1.200, 9.26, 1.200, 9.26,
↪ 1, 0.000; 1.500
SV196 bogie 1 Axle 2 critical, 37.88, 4, 1, 9.26, 1.200, 10.10, 1.200, 9.26, 1.200, 9.26,
↪ 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified loads, Low speed (<= 10mph)

%GROUP: SV196 bogie 1 Low speed - Note: Needs 1.5m min AND to suit edge distances
```

7 Vehicles

```
SV196 bogie 1 Axle 1 critical, 35.99, 4, 1, 9.60, 1.200, 8.80, 1.200, 8.80, 1.200, 8.80, 1,  
  ⇨ 0.000; 1.500  
SV196 bogie 1 Axle 2 critical, 35.99, 4, 1, 8.80, 1.200, 9.60, 1.200, 8.80, 1.200, 8.80, 1,  
  ⇨ 0.000; 1.500  
  
%FAMILY: SV Bogies as single wheels, Certified axles, Low speed (<= 10mph)  
  
%GROUP: SV196 bogie 1 Low speed - Note: Needs 1.5m min AND to suit edge distances  
  
SV196 bogie 1 Axle 1 critical, 33.67, 4, 1, 8.42, 1.200, 8.42, 1.200, 8.42, 1.200, 8.42, 1,  
  ⇨ 0.000; 1.500  
SV196 bogie 1 Axle 2 critical, 33.67, 4, 1, 8.42, 1.200, 8.42, 1.200, 8.42, 1.200, 8.42, 1,  
  ⇨ 0.000; 1.500
```

7.6.2 Bogie 2 (5 axles)

```
%FAMILY: SV Bogies as single wheels, Normal speed (> 10mph)  
  
%GROUP: SV196 bogie 2 No lift-off - Note: Needs 1.5m min AND to suit edge distances  
  
SV196 bogie 2 Axle 1 critical, 52.63, 5, 1, 11.28, 1.200, 10.34, 1.200, 10.34, 1.200,  
  ⇨ 10.34, 1.200, 10.34, 1, 0.000; 1.500  
SV196 bogie 2 Axle 2 critical, 52.63, 5, 1, 10.34, 1.200, 11.28, 1.200, 10.34, 1.200,  
  ⇨ 10.34, 1.200, 10.34, 1, 0.000; 1.500  
SV196 bogie 2 Axle 3 critical, 52.63, 5, 1, 10.34, 1.200, 10.34, 1.200, 11.28, 1.200,  
  ⇨ 10.34, 1.200, 10.34, 1, 0.000; 1.500  
  
%GROUP: SV196 bogie 2 Lift-off - Note: Needs 1.5m min AND to suit edge distances  
  
SV196 bogie 2 Axle 1 critical, 52.82, 5, 1, 13.53, 1.200, 10.34, 1.200, 8.27, 1.200, 10.34,  
  ⇨ 1.200, 10.34, 1, 0.000; 1.500  
SV196 bogie 2 Axle 2 critical, 52.82, 5, 1, 10.34, 1.200, 13.53, 1.200, 10.34, 1.200, 8.27,  
  ⇨ 1.200, 10.34, 1, 0.000; 1.500  
SV196 bogie 2 Axle 3 critical, 52.82, 5, 1, 10.34, 1.200, 10.34, 1.200, 13.53, 1.200,  
  ⇨ 10.34, 1.200, 8.27, 1, 0.000; 1.500
```

7 Vehicles

```
%FAMILY: SV Bogies as single wheels, Low speed (<= 10mph)

%GROUP: SV196 bogie 2 Low speed - Note: Needs 1.5m min AND to suit edge distances

SV196 bogie 2 Axle 1 critical, 47.14, 5, 1, 10.10, 1.200, 9.26, 1.200, 9.26, 1.200, 9.26,
  ⇨ 1.200, 9.26, 1, 0.000; 1.500
SV196 bogie 2 Axle 2 critical, 47.14, 5, 1, 9.26, 1.200, 10.10, 1.200, 9.26, 1.200, 9.26,
  ⇨ 1.200, 9.26, 1, 0.000; 1.500
SV196 bogie 2 Axle 3 critical, 47.14, 5, 1, 9.26, 1.200, 9.26, 1.200, 10.10, 1.200, 9.26,
  ⇨ 1.200, 9.26, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified loads, Low speed (<= 10mph)

%GROUP: SV196 bogie 2 Low speed - Note: Needs 1.5m min AND to suit edge distances

SV196 bogie 2 Axle 1 critical, 44.79, 5, 1, 9.60, 1.200, 8.80, 1.200, 8.80, 1.200, 8.80,
  ⇨ 1.200, 8.80, 1, 0.000; 1.500
SV196 bogie 2 Axle 2 critical, 44.79, 5, 1, 8.80, 1.200, 9.60, 1.200, 8.80, 1.200, 8.80,
  ⇨ 1.200, 8.80, 1, 0.000; 1.500
SV196 bogie 2 Axle 3 critical, 44.79, 5, 1, 8.80, 1.200, 8.80, 1.200, 9.60, 1.200, 8.80,
  ⇨ 1.200, 8.80, 1, 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified axles, Low speed (<= 10mph)

%GROUP: SV196 bogie 2 Low speed - Note: Needs 1.5m min AND to suit edge distances

SV196 bogie 2 Axle 1 critical, 42.09, 5, 1, 8.42, 1.200, 8.42, 1.200, 8.42, 1.200, 8.42,
  ⇨ 1.200, 8.42, 1, 0.000; 1.500
SV196 bogie 2 Axle 2 critical, 42.09, 5, 1, 8.42, 1.200, 8.42, 1.200, 8.42, 1.200, 8.42,
  ⇨ 1.200, 8.42, 1, 0.000; 1.500
SV196 bogie 2 Axle 3 critical, 42.09, 5, 1, 8.42, 1.200, 8.42, 1.200, 8.42, 1.200, 8.42,
  ⇨ 1.200, 8.42, 1, 0.000; 1.500
```

7.6.3 SV196/SVTrain Tractor

The tractor is the same for the SV196 load model from CS454 and the SVTrain model in BD86.

7 Vehicles

```
%FAMILY: SV Bogies as single wheels, Normal speed (> 10mph)

%GROUP: SV196/SVTrain Tractor No lift-off - Note: Needs 1.5m min AND to suit edge distances

SV196/SVTrain Tractor Axle 2 critical, 30.03, 3, 1, 6.75, 4.400, 12.14, 1.600, 11.13, 1,
⇨ 0.000; 1.500
SV196/SVTrain Tractor Axle 3 critical, 30.03, 3, 1, 6.75, 4.400, 11.13, 1.600, 12.14, 1,
⇨ 0.000; 1.500

%GROUP: SV196/SVTrain Tractor Lift-off - Note: Needs 1.5m min AND to suit edge distances

SV196/SVTrain Tractor Axle 2 critical, 30.23, 3, 1, 6.75, 4.400, 14.57, 1.600, 8.91, 1,
⇨ 0.000; 1.500
SV196/SVTrain Tractor Axle 3 critical, 30.23, 3, 1, 6.75, 4.400, 8.91, 1.600, 14.57, 1,
⇨ 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Low speed (<= 10mph)

%GROUP: SV196/SVTrain Tractor Low speed - Note: Needs 1.5m min AND to suit edge distances

SV196/SVTrain Tractor Axle 2 critical, 26.73, 3, 1, 5.61, 4.400, 11.02, 1.600, 10.10, 1,
⇨ 0.000; 1.500
SV196/SVTrain Tractor Axle 3 critical, 26.73, 3, 1, 5.61, 4.400, 10.10, 1.600, 11.02, 1,
⇨ 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified loads, Low speed (<= 10mph)

%GROUP: SV196/SVTrain Tractor Low speed - Note: Needs 1.5m min AND to suit edge distances

SV196/SVTrain Tractor Axle 2 critical, 25.40, 3, 1, 5.33, 4.400, 10.47, 1.600, 9.60, 1,
⇨ 0.000; 1.500
SV196/SVTrain Tractor Axle 3 critical, 25.40, 3, 1, 5.33, 4.400, 9.60, 1.600, 10.47, 1,
⇨ 0.000; 1.500

%FAMILY: SV Bogies as single wheels, Certified axles, Low speed (<= 10mph)

%GROUP: SV196/SVTrain Tractor Low speed - Note: Needs 1.5m min AND to suit edge distances

SV196/SVTrain Tractor Axle 2 critical, 23.47, 3, 1, 5.10, 4.400, 9.18, 1.600, 9.18, 1,
⇨ 0.000; 1.500
```

7 Vehicles

```
SV196/SVTrain Tractor Axle 3 critical, 23.47, 3, 1, 5.10, 4.400, 9.18, 1.600, 9.18, 1,  
↔ 0.000; 1.500
```

7.7 SVTT

Note that the SVTT Trailer load has 4 wheels across the axle and is treated as an axle load.

A complete assessment for SVTT will involve creating two variant bridge models, with different widths, and running both the relevant “SV Bogies as single wheels” load family, and the relevant “SVTT Trailer” family.

7.7.1 SVTT Tractor

```
%FAMILY: SV Bogies as single wheels, Normal speed (> 10mph)  
  
%GROUP: SVTT Tractor No lift-off - Note: Needs 1.5m min AND to suit edge distances  
  
SVTT Tractor Axle 2 critical, 34.99, 3, 1, 9.53, 4.000, 13.28, 1.500, 12.17, 1, 0.000; 1.500  
SVTT Tractor Axle 3 critical, 34.99, 3, 1, 9.53, 4.000, 12.17, 1.500, 13.28, 1, 0.000; 1.500  
  
%GROUP: SVTT Tractor Lift-off - Note: Needs 1.5m min AND to suit edge distances  
  
SVTT Tractor Axle 2 critical, 35.21, 3, 1, 9.53, 4.000, 15.94, 1.500, 9.74, 1, 0.000; 1.500  
SVTT Tractor Axle 3 critical, 35.21, 3, 1, 9.53, 4.000, 9.74, 1.500, 15.94, 1, 0.000; 1.500  
  
%FAMILY: SV Bogies as single wheels, Low speed (<= 10mph)  
  
%GROUP: SVTT Tractor Low speed - Note: Needs 1.5m min AND to suit edge distances  
  
SVTT Tractor Axle 2 critical, 31.89, 3, 1, 8.42, 4.000, 12.24, 1.500, 11.22, 1, 0.000; 1.500  
SVTT Tractor Axle 3 critical, 31.89, 3, 1, 8.42, 4.000, 11.22, 1.500, 12.24, 1, 0.000; 1.500  
  
%FAMILY: SV Bogies as single wheels, Certified loads, Low speed (<= 10mph)  
  
%GROUP: SVTT Tractor Low speed - Note: Needs 1.5m min AND to suit edge distances
```

7 Vehicles

```
SVTT Tractor Axle 2 critical, 30.29, 3, 1, 8.00, 4.000, 11.63, 1.500, 10.66, 1, 0.000; 1.500
SVTT Tractor Axle 3 critical, 30.29, 3, 1, 8.00, 4.000, 10.66, 1.500, 11.63, 1, 0.000; 1.500
```

```
%FAMILY: SV Bogies as single wheels, Certified axles, Low speed (<= 10mph)
```

```
%GROUP: SVTT Tractor Low speed - Note: Needs 1.5m min AND to suit edge distances
```

```
SVTT Tractor Axle 2 critical, 28.06, 3, 1, 7.65, 4.000, 10.20, 1.500, 10.20, 1, 0.000; 1.500
SVTT Tractor Axle 3 critical, 28.06, 3, 1, 7.65, 4.000, 10.20, 1.500, 10.20, 1, 0.000; 1.500
```

7.7.2 SVTT Trailer

The last load in the set, but it needs a different treatment. The SVTT trailer is a pair of axles with four wheels, equally spaced across the width. The transverse distributions from these will generally intersect, so the full axle is given. The axle width is 3.0m. 3.7m width is required to carry the vehicle.

```
%FAMILY: SVTT Trailer full width, Normal speed (> 10mph)
```

```
%GROUP: SVTT Trailer No lift-off - Note: Needs 3.7m min width
```

```
SVTT Trailer Axle 1 critical, 61.61, 2, 1, 32.14, 1.500, 29.46, 1, 3.000; 3.700
```

```
%GROUP: SVTT Trailer Lift-off - Note: Needs 3.7m min width
```

```
SVTT Trailer Axle 1 critical, 62.14, 2, 1, 38.57, 1.500, 23.57, 1, 3.000; 3.700
```

```
%FAMILY: SVTT Trailer full width, Low speed (<= 10mph)
```

```
%GROUP: SVTT Trailer Low speed - Note: Needs 3.7m min width
```

```
SVTT Trailer Axle 1 critical, 58.67, 2, 1, 30.61, 1.500, 28.06, 1, 3.000; 3.700
```

```
%FAMILY: SVTT Trailer full width, Certified loads, Low speed (<= 10mph)
```

7 Vehicles

%GROUP: SVTT Trailer Low speed - Note: Needs 3.7m min width

SVTT Trailer Axle 1 critical, 55.74, 2, 1, 29.08, 1.500, 26.66, 1, 3.000; 3.700

%FAMILY: SVTT Trailer full width, Certified axles, Low speed (<= 10mph)

%GROUP: SVTT Trailer Low speed - Note: Needs 3.7m min width

SVTT Trailer Axle 1 critical, 51.02, 2, 1, 25.51, 1.500, 25.51, 1, 3.000; 3.700

8 Load file

The complete set of loads is assembled in the file `sv_loads.ldf`. This file is included in the Archie-M distribution, so the various families should appear in the standard load list.